Ravi Kumar

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Education

Indian Institute of Technology, Bombay   *October '21 - Present*
Dept. of Aerospace Engineering   *CPI: 8.22/10*
Bachelor of Technology in **Aerospace Engineering** with Minor in **Data Science and Artificial Intelligence**

Research Experience

Optimization of Pipelines for GROWTH India Telescope (GIT)   *May '23 - Present*
Guide: Prof. Varun Bhalerao, Dept. of Physics, IIT Bombay

Data Reduction

- Improved the **image subtraction** pipeline by exploring different source masking techniques and developed a method to compute the net **efficiency** of image subtraction performed on a particular image.
- Implemented **weighted stacking** of processed science images using **SWarp** and standard deviation **weight-maps** to deliver better **limiting magnitude** and overall SNR compared to the conventional median stacking.

Electro-Magnetic counterparts to Gravitational Waves (EMGW)

- Processed Ultra Violet Imaging Telescope (**UVIT**) data and calculated the upper limit of **GRB 220408A**.
- Working with **Slack** bots to complete the transition of the existing GCN alert system to **Kafka**.

Observational Experience

- Discovered a new optical transient AT 2023tkw in the host galaxy Messier 31 and published the results on the Transient Name Server (**TNS**) - AstroNote 2023-255, and the Astronomer's Telegram - ATel 16311
- Performed optical follow-ups and data reduction on multiple GRBs and published the results as **NASA GCN Circulars** - GCN 34839, 34833, 34780, 34576, 34514, 34500, 34460, 34420.
- Carried out observations and calculations for multiple **possible comet** and Near Earth Object (**NEO**) and published the results on the **Minor Planet Center** - MPEC 2023-S264, 2023-R197, 2023-R115, 2023-O51.
- Performed calculations on tiling of past **Fermi GBM** localisations to determine coverage capabilities and follow-up criteria using GIT. Results include the follow-up of **GRB 231018A** (GCN 34839) covering $\sim$ **22%** of the probability.

Key Projects

Statistically Detecting Gamma Ray Bursts in CZTI | Github   *May '23 - July '23*
Krittika Summer Projects, Guides: Gaurav Waratkar, Meghna Dixit - IIT Bombay

- Studied physics of Gamma Ray Bursts (**GRB**s) and working of **AstroSat**'s Cadmium-Zinc-Telluride Imager (**CZTI**).
- Generated and analyzed multiple time-binned light curves, spectral plots, spectrogram, and detector plane histogram for **GRB 190928A** in Python by using the data reduction modules from the **CZT Pipeline**.
- Analyzed the unknown distribution of noise data present in the light curves by fitting various known distributions, namely the **Gaussian**, **Poisson**, **SkewNorm** and **Gamma** distributions and statistically determined the best fit.
- Established a quantitative method to determine whether the true nature of a given signal is **cosmic** or **real** by determining the Signal to Noise Ratio (**SNR**) across different energy ranges and comparing the results.
- Designed and implemented a pipeline to accurately **uncover possible GRBs** using time-binned statistics for any given orbit file with testing done against **10** different known GRBs to achieve a success rate of **90%**.

Time Series Analysis of Magnetic Cataclysmic Variables | Report   *May '23 - July '23*
Krittika Summer Projects, Guide: Abhinna Sundar - Max Planck Institute for Astronomy

- Studied the physics governing **binary stars** and cataclysmic variables (**CVs**) with emphasis on **magnetic** CVs.
- Performed **image reduction** and statistical analysis on data of the **polar** magnetic cataclysmic variable **BL Hydri** obtained from **AstroSat**'s Ultra Violet Imaging Telescope (**UVIT**) by the use of **CCDLAB**.
- Performed generation of light curves using the UVIT-specific data processing library **curvit** and accurately obtained the **orbital period** of the system by analyzing the **Lomb–Scargle Periodogram** of the light curve.
- Performed **phase folding** and correction of **ephemeris** on the obtained light-curve, furthermore, calculated the magnitudes, fluxes, and luminosities associated with each phase to determine the **physical state** of the system.

Stellar Analysis of Clusters using Gaia | Report
Krittika Summer Projects   *May '23 - July '23*

- Employed parallax and proper motion cuts on a dataset of **1 billion+** stars to find distances of 5 open clusters.
- Studied the **phase space distribution** of spectral types in open clusters and obtained the **Salpeter** Initial Mass Function (**IMF**) by using a comparison between **HR diagrams** and **PARSEC isochrones**.
- Obtained the age and metallicity of the globular cluster **Omega Centauri** by fitting isochrones on its HR diagram.

Analysis of Solar Flares and Prediction of Solar Activity | Github
Data Analysis (DS203) Course Project, Prof. Amit Sethi, Prof. Manjesh K. Hanawal   *August '22 - November '22*

- Studied the underlying physics associated with **solar flares and activity**, and gathered datasets for analysis.
- Analysed the time series data from the Reuven Ramaty High Energy Solar Spectroscopic Imager (**RHESSI**) and **Konus-Wind** missions using both Long Short Term Memory (**LSTM**) and **Autoregressive** models.
- LSTM: Achieved a mean squared error of **0.021** and **0.026** on the RHESSI and Konus-Wind datasets respectively.
- Autoregression: Achieved a mean squared error of **0.012** and **0.017** on RHESSI and Konus-Wind datasets respectively.

Weather Classification via Computer Vision | Github
Machine Learning (DS303) Course Project, Guide: Prof. Biplab Banerjee   *January '23 - April '23*

- Implemented a **ConvNet** model for transfer learning with **VGG16** backbone pre-trained on the **ImageNet** dataset
- Achieved an unprecedented validation accuracy of **85.61%**, seeing an improvement of **5.34%** over the original model.
- **Fine-tuned** the model with a head consisting of **flatten, dense** and **dropout** layers to improve accuracy by **4.38%**

Correlation Between JEE Rank and Branch Chosen | Github
Data Analysis (AE102) Course Project, Guide: Prof. Amuthan Ramabathiran   *April '22 - July '22*

- Collected and filtered data from the **JoSAA** website to study the trend of popularity of branches at various IITs.
- Plotted the data and observed a **gradual shift** in the average ranks accepted into the **CSE** and **Electrical** branches.

Structural Analysis on Variable-Sweep Wing Aircraft
Structures (AE238) Course Project, Guide: Prof. Amuthan Ramabathiran   *January '23 - April '23*

- Performed comprehensive study on aerodynamic effects based on the **Grumman F-14 Tomcat** and built a simple working model with **servo actuators**, to demonstrate the **variable-sweep wing** characteristics of the aircraft.
- Analyzed and reported the variation of **aeroelastic effects** like **flutter** and **divergence** with change in sweep angle.

Positions of Responsibility

Team Krittika - Volunteer
The Astronomy Club of IIT Bombay   *December '22 - April '23*

- Increased astronomy awareness in the institute by conducting a stargazing session by employing Electronically Assisted Astronomy (**EAA**) to display live footage of **comet C/2022 E3 (ZTF)** for an audience of **250+** students.
- Assisted in club outreach by regularly capturing and posting images of deep sky objects such as the **Orion Nebula**, **Leo Triplet**, and **Omega Centauri** along with a **transit** of the **International Space Station** across the Sun.

Scholastic Acheivements

Top 0.73%, Joint Entrance Examination Mains among over **0.9 million** candidates   *February 2021*

Top 1.15%, Joint Entrance Examination Advanced among over **0.14 million** candidates   *October 2021*

Courses Undertaken

Aerospace	Spaceflight Mechanics, Compressible and Incompressible Fluid Mechanics, Aircraft Propulsion
Mathematics	Numerical Analysis, Partial Differential Equations, Multi-variable Calculus, Linear Algebra
Data Science	Machine Learning, Programming for Data Science, Data Analysis and Interpretation
Other	Quantum Physics and Application, Basics of Electricity and Magnetism, Introduction to Electrical and Electronics Circuits, Computer Programming and Utilization

Technical Skills

Languages	Python, C++, SQL, HTML5, CSS, LaTeX
Softwares	CCDLAB, SWarp, SExtractor, DS9, Siril
Libraries	AstroPy, NumPy, HealPy, SciPy, Pandas, Matplotlib, OpenCV, curvit