Haleh Hajizadeh

Curriculum Vitae

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Personal Information and Contact

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Education

2017–2020 **MSc in Computational Cosmology**
Shahid Beheshti University (SBU), Tehran, Iran

Thesis In the search of cosmic string on Planck's data with image processing, statistical tools and machine learning methods

Advisers Marzieh Farhang, Alireza Vafaei Sadr

2012–2016 **BSc in Physics**
Univesity of Tabriz, Tabriz, Iran

Research Interests

- **Astronomy:** Data from Telescopes, Radio Astronomy, Image Processing, Photometry, Star Formation, Stellar Generations, Galaxy Evolution, Evolution of The Universe
- **Cosmology:** Cosmic Microwave Background, Topological defects, Planck's Data
- **Data Science, Machine Learning and Deep Learning:** Especially in physics

Research Experiences

2021 **Classification of Galaxies based on their Infalling Time and Loss Mass in Galaxy groups with Machine Learning**. I recently started this project with Dr. Ghassem Gozaliasl (postdoctoral researcher at the University of Helsinki). The behavior of galaxies in the groups or clusters is important because it gives us information like their star formation rate and galaxy's morphological transformation. In this project, we want to study the features of galaxies in groups, such as their infalling time (time that a galaxy spent in a group or cluster) and loss mass and their correlations. Finally, we want to classify galaxies based on their features. We are in the beginning phase of the project, and till now, we have done some visualizations to explore data.

2020 **Searching for the relationship between Signal to Noise Ratio (SNR) and exposure time in Iranian National Observatory Lens Array (INOLA)**. I started this project at the School of Astronomy of IPM (Institute for Research in Fundamental Sciences) in a group under the supervision of Dr. Habib Khosroshahi (professor at IPM). Our purpose is to find a correlation between SNR with exposure time, filter type, and other parameters that can affect SNR. This project helps us know how long we need to expose an object to reach a specific SNR through several filters in INOLA. This project is ongoing now, and I'm trying to get the goals of the project. During this work, I learned some astronomical software like IRAF, DS9, and Aladin.

2019 **PLAsTiCC (Photometric LSST Astronomical Time-Series Classification Challenge)**. This was the topic of competition on the Kaggle website (link). The task was to classify astronomical sources in the Large Synoptic Survey Telescope (LSST) simulation data into different classes to prepare an efficient algorithm for analyzing real data from the telescope. My teammates and I worked on this project as the final assignment of the data science workshop series at IPM. The supervisor of this project was Dr. Fatemeh Tabatabaei (professor at IPM). I did the following tasks in this work:

- Data preparation, preprocessing, and visualization to explore data.
- Feature extraction using different astronomical libraries.
- Build and fit a LightGBM model on the training dataset.
- Apply the trained model on the test dataset to evaluate its performance.
- Loss of our model on the test dataset is 0.80, while the first winner's loss was 0.68.
- According to loss score, our model is the 7th top-ranked among over 1000 models.

2018–2020 **Planck Limits on Cosmic String Tension Using Machine Learning**. This is my master thesis topic. My supervisors were Dr.Marzieh Farhang (assistant professor at SBU) and Dr.Alireza Vafaei Sadr (postdoctoral researcher at the University of Geneva). In this project, our purpose was to find cosmic strings footprints on Planck's data. Cosmic strings are important because some theories predict that they could have been produced during phase transition in the early universe. The presence or absence of cosmic strings in the universe can accept or reject theories about phase transitions in the early universe. Using Planck's data, we constrained the tension (the main parameter characterizing the string network) of cosmic string ($G\mu$). We did the following steps to get our results:

- Use several CMB and cosmic string network simulations to build and test classification models.
- Use image processing steps like Curvelet decomposition and Canny Filtering to increase the detectability of cosmic string signature.
- Quantify the possible imprints by applying statistical measures like standard deviation and probability density function.
- Use different machine learning algorithms such as Decision Tree, Random Forest, Gradient Boosting, k-Nearest Neighbors (KNN), Naive Bayes, LightGBM, XGBoost, etc., to detect cosmic string.
- Apply the model with the highest performance (LightGBM) on Planck's data to find the bound on the tension of cosmic string on observational data.
- Result: found no observable trace and yielded upper limit of $G\mu \leq 8.6 \times 10^{-7}$ with 3σ confidence level.

Publications

- **Planck Limits on Cosmic String Tension Using Machine Learning**
  Accepted to be published in Monthly Notices of the Royal Astronomical Society (MNRAS)(link)

Teaching Experiences

2020 **Teaching Assistant in BSc Astrophysics Course**

- by Dr.Marzieh Farhang
- Textbook: "Astronomy A Physical Perspective" by Marc L.Kutner

Coferance Publications

- **Neural Networks in the Search of Cosmic Strings**
  Motahareh Torki, Haleh Hajizadeh, Alireza Vafaei Sadr, Marzieh Farhang
  National Conference on Gravity and Cosmology (2019)
- **In the Search of Cosmic Strings in Planck's data**
  Haleh Hajizadeh, Motahareh Torki, Alireza Vafaei Sadr, Marzieh Farhang.
  The Annual Physics Conference of Iran (2019)

- **Machine Learning Approach to the Photometric Data Analysis of PLAsTiCC Astronomical Challenge**
  Mahya Besharati, Shideh DavarPanah, Haleh Hajizadeh, Nikoo HoseiniNejad, Nazanin Saadat Moghadam, Arghavan Souki, Motahareh Torki, Fatemeh Tabatabaei, Alireza Vafaei Sadr.
  National Conference on Gravity and Cosmology (2020)
- **Machine Learning Approaches to Photometric LSST Astronomical Time-Series Classification (PLAsTiCC)**
  Mahya Besharati, Shideh DavarPanah, Haleh Hajizadeh, Nikoo HoseiniNejad, Nazanin Saadat Moghadam, Arghavan Souki, Motahareh Torki, Fatemeh Tabatabaei, Alireza Vafaei Sadr.
  National Conference of Iranian Observatories (2020)

Computer skills

- **Programming Languages:** Python, Bash
- **Markup Languages:** LaTeX
- **Version Control Systems (VCS):** Git, Github
- **Text Editors and Notebooks:** Jupyter-Notebook, Visual Studio Code
- **Operating Systems (OS):** Linux, Windows
- **Computational Softwares:** Wolfram Mathematica
- **Astronomical Softwares:** SAO image (ds9), IRAF, Aladin, TOPCAT

Data Science and Machine Learning Skills

- **SQL:** Write queries to get data from relational databases
- **Data Cleaning and Pre-processing**
- **Data Visualization:** matplotlib (Python), seaborn (Python), Mathematica
- **Data Analysis:** numpy (Python), pandas (Python)
- **Statistics**
- **Machine Learning:** scikit-learn, LightGBM, XGBoost

Certificates

2020 **Introduction to Git and Github** by Javad Ebadi on SciShool. Certificate earned at 9 Mar 2021(Link)

2020 **Data-driven Astronomy** by Sydney University on Coursera. Certificate earned at 20 Aug 2020 (Link)

Selected Talks and Posters

Talk **Machine Learning Approach to the Photometric Data Analysis of PLAsTiCC Astronomical Challenge** (National Conference on Gravity and Cosmology - 2020)

Poster **Machine Learning Approaches to Photometric LSST Astronomical Time-Series Classification (PLAsTiCC)** (National Conference of Iranian Observatories - 2020)

Poster **In the Search of Cosmic Strings in Planck's data** (The Annual Physics Conference of Iran - 2019)

Poster **Neural Networks in the Search of Cosmic Strings** (National Conference on Gravity and Cosmology - 2019)

Selected School, Workshops and Conferences

- IPM workshop on Radio Astronomy: Observation and Data Reduction (IPM - 2021)
- SBU workshop on Machine Learning in Astronomy and Cosmology (SBU - 2019)
- IPM school on Data Science (IPM - 2019)
- IPM conference on Baryons in Galaxies and Beyond (IPM - 2019)
- IPM conference on Cosmology: from theory to observation (IPM - 2018)

Languages

- **English** (Upper Intermediate)
- **Persian** (Native)
- **Azerbaijani** (Native)
- **Turkish** (Novice High)

References

Marzieh Farhang

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Ghassem Gozaliasl

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Alireza Vafaei Sadr

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