Mouza Almualla

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Research Interests

I am interested in the intersection of theory and data in various fields within astrophysics. In the past, I have worked on compact object mergers detected by LIGO, both in LIGO to help detect them, and with the Zwicky Transient Facility to search for their optical counterparts. My recent research has mostly revolved around optimizing the detection of EM counterparts to compact object mergers, as well as using radiative transfer simulations to better understand their ejecta structure.

Education

Bachelor of Science in Physics Sep. 2017 - May 2022
Bachelor of Science in Electrical Engineering Sep. 2017 - May 2022
American University of Sharjah, *summa cum laude*

PhD in Astronomy and Astrophysics Starting Sep. 2022
Harvard University

Awards and Honors

Chancellor's List Scholarship, (2017 - Present)
Distinguished Student Scholarship, (2017 - Present)
Dean's List Scholarship, (2017 - Present)
Regional Winner in *Mathematics and Physics*, Global Undergraduate Awards (2021)
Highly Commended Entrant (top 10%) in *Mathematics and Physics*, Global Undergraduate Awards (2021)
1st Place, Explore Mars Poster Competition (2019)

Skills

- Programming languages: Python, MATLAB, C/C++
- Operating systems: Mac OS, Linux
- Software: LaTeX, Git, Bash Scripting, Ansys HFSS, LabVIEW, PSPICE

Research Experiences

Constraining Kilonova Ejecta Geometries using POSSIS August 2021 - Present
Physics Senior Research Project
Mentored by Dr. Michael Coughlin (UMN), Dr. Mattia Bulla (Stockholm U.) and Dr. Nidhal Guessoum (AUS)

- Produced multiple large-scale kilonova grids using radiative transfer simulations
- Showed that incorporating an angular dependency in one of the ejecta components improves best-fit to GW170817 by 50%

Deepfake detection using Visual Transformers and Autoencoders Jan 2021 - Present
Electrical Eng. Senior Design Project
Mentored by Dr. Usman Tariq (AUS) and Dr. Abhinav Dhall (Monash U.)

- Incorporated autoencoder and visual transformer architectures into deepfake detection pipeline
- Achieved accuracies of up to $\sim 90\%$

Serendipitous Observations of Kilonovae July 2020 - April 2021
University of Minnesota Summer Research Program
Mentored by Dr. Michael Coughlin (UMN) and Shreya Anand (Caltech)

- Generated realistic simulations of survey observations conducted by the Zwicky Transient Facility (ZTF)
- Evaluated the efficiency of different survey strategies in detecting kilonovae to help strategize for Phase II of ZTF
- Published journal paper describing these optimal survey strategies and the resulting improvements.

LIGO Noise Subtraction and Detector Characterization July - Oct. 2020
University of Minnesota Summer Research Program
Mentored by Dr. Michael Coughlin (UMN) and Dr. Guillermo Valdes (LSU)

- Tested and optimized a noise subtraction pipeline that utilizes machine learning methods using gravitational-wave events from the second and third observing runs of LIGO
- Participated in LIGO Detector Characterization Noise Sprint working on intermittent noise investigations

Optimizing Detection of EM Counterparts to Gravitational Waves July 2019 - Present
LIGO Lab, California Institute of Technology
Mentored by Dr. Nidhal Guessoum (AUS) and Dr. Michael Coughlin (UMN)

- Spent one month at Caltech developing improvements to the scheduling software used for Target of Opportunity observations conducted by the GROWTH Collaboration
- Published journal paper describing scheduling improvements

Publications

Almualla, M., Ning, Y., Bulla, M., Dietrich, T., Coughlin, M.W., and Guessoum, N., "Using Neural Networks to Perform Rapid High-Dimensional Kilonova Parameter Inference" (2022), *arXiv:2112.15470*, https://arxiv.org/abs/2112.15470.

Almualla, M., Anand, S., Coughlin, M.W., Dietrich, T., Guessoum, N., Sagues Carracedo, A., Ahumada, T., Andreoni, I., Antier, S., Bellm, E.C., Bulla, M. and Singer, L.P., "Optimizing Serendipitous Detections of Kilonovae: Cadence and Filter Selection" (2021), *Monthly Notices of the Royal Astronomical Society*, 504(2), 2822–2831.

Ahumada, T., Singer, L.P.,..., **Almualla, M.** et al., "Discovery and confirmation of the shortest gamma-ray burst from a collapsar" (2021), *Nature Astronomy*, doi:10.1038/s41550-021-01428-7

Anand, S., Coughlin, M.W.,..., **Almualla, M.** et al., "Optical follow-up of the neutron star–black hole mergers S200105ae and S200115j" (2021), *Nature Astronomy*, 5(1), 46–53

Kasliwal, M.M., Anand, S.,..., **Almualla, M.**, et al., "Kilonova Luminosity Function Constraints Based on Zwicky Transient Facility Searches for 13 Neutron Star Merger Triggers during O3" (2020), *The Astrophysical Journal*, 905(2), 145

Antier, S., Agayeva, S., **Almualla, M.**, et al., "GRANDMA Observations of Advanced LIGO's and Advanced Virgo's Third Observational Campaign" (2020), *Monthly Notices of the Royal Astronomical Society*, 497(4), 5518–5539

Coughlin, M.W., Dietrich, T., Antier, S., **Almualla, M.**, Anand, S., Bulla, M., Foucart, F., Guessoum, N., Hotokezaka, K., Kumar, V., Raajimakers, G., and Nissanke, S., "Implications of the search for optical counterparts during the second part of the Advanced LIGO's and Advanced Virgo's third observing run: lessons learned for future follow-up observations" (2020), *Monthly Notices of the Royal Astronomical Society*, 497(1), 1181 - 1196

Almualla, M., Coughlin, M.W., Anand, S., Alqassimi, K., Guessoum, N., and Singer, L.P., "Dynamic scheduling: target of opportunity observations of gravitational wave events" (2020), *Monthly Notices of the Royal Astronomical Society*, 495(4), 4366–4371

Coughlin, M.W., Antier, S., Corre, D., Alqassimi, K., Anand, S., Christenen, N., Coulter, D.A., Foley, R.J., Guessoum, N., Mikulski, T.M., **Almualla, M.**, Reed, D., Tao, D., "Optimizing multitelescope observations of gravitational-wave counterparts" (2019), *Monthly Notices of the Royal Astronomical Society*, 489(4), 5775–5783

Talks

July 2021 - *"Optimizing Searches for Serendipitous Kilonovae by Wide-Field Surveys"*
GRANDMA Collaboration Seminars

January 2021 - *"Dynamic Scheduling: Target of Opportunity Observations of Gravitational-Wave Events"*
43rd COSPAR Scientific Assembly

November 2020 - *"Optimizing Searches for Serendipitous Kilonovae by Wide-Field Surveys"*
5th Middle East and Africa Regional IAU Meeting

September 2020 - *"Investigating intermittent, sharp-frequency noise within the GW strain"*
LIGO Detector Characterization Telecon

August 2020 - *"Optimizing Searches for Serendipitous Kilonovae by Wide-Field Surveys"*
GROWTH Multi-Messenger Astronomy Teleconference

September 2019 - *"Exploring Statistical Differences Between Swift and Fermi Burst Measurements"*
15th Gulf Astronomy Colloquium
Sharjah Academy for Astronomy, Space Sciences, and Technology, Sharjah, UAE

September 2019 - *"Scheduling Improvements to GW Target of Opportunity Scheduler `GWEMOPT`"*
GROWTH Multi-Messenger Astronomy Teleconference

Posters

January 2021 - *"Dynamic Scheduling: Target of Opportunity Observations of Gravitational-Wave Events"*

43rd COSPAR Scientific Assembly

January 2019 - *"Trans-atmospheric Radio Communication on Mars During Solar Energetic Particle Events"*
Mohammed Bin Rashid Space Centre Explore Mars Competition

Relevant Coursework

Physics: Classical Mechanics, Electromagnetism, Quantum Mechanics, Statistical Mechanics and Thermal Physics, Mathematical Methods for Physics, Fluid Mechanics and Optics, Satellites and Space Physics, Astrophysics

Mathematics and Electrical Eng.: Calculus (I, II, and III), Differential Equations, Linear Algebra, Statistics, Control Systems, Probability and Stochastic Processes, Programming I (C++), Neural Networks in Machine Learning

Outreach

Vice Chair, IEEE AUS Main Branch — Jan. - May 2019

- IEEE (Institute of Electrical and Electronics Engineers) is the largest worldwide technical organization, and focuses on the advance of research and knowledge for the benefit of humanity.
- Organized and managed events, prioritized certain events/tasks, assigned roles.
- Took on Chair's duties when necessary.

Interview for Mars Poster Competition Winners, Sharjah TV — April 2019

- Discussed my poster on Martian ionospheric studies, which won first place at our national space center's annual science event.

Public Relations Officer, IEEE AUS Main Branch — Sep. - Dec. 2018

- Handled correspondence with other organizations and professors.
- Handled social media, posters, and event promotion.

Executive Secretary, College of Arts and Sciences Student Team — Sep. - Dec. 2018

- Arranged meetings, kept agendas and took minutes.
- Coordinated between the team and different parts of the university, arranged collaborative events.

Organizer, Gamma Ray Burst Workshop (Hotel Hilton, Sharjah) — Oct. 2018

- Engaged in pre-event organization and promotion, and helped provide needed supplies.
- Helped participants and speakers throughout the event to ensure it ran smoothly.