Atul Kedia

Physics PhD Candidate
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Education

Present **Ph.D. Candidate**, *University of Notre Dame*, Physics, Expected graduation 2022.

2016-20 **M.S.**, *University of Notre Dame*, Physics.

2012-16 **B.Tech.**, *Indian Institute of Technology Bombay*, Engineering Physics with Honors.
Exchange Semester - Spring 2015 at *University of Toronto*.

Research Experience

Neutron star mergers and the nuclear equation of state *(2019 - present)*

Collaborators: Prof. Grant Mathews[1], Dr. Hee Il Kim[2], & Dr. In-Saeng Suh[1]

[1] University of Notre Dame, [2] Sogang University, Seoul, South Korea.

- We construct binary neutron star merger simulations for neutron stars described with a parametrizes Quark-Hadron crossover (QHC) equation of state (EoS) and various other liquid nuclear matter EoSs with full general relativistic hydrodynamics. We report stark differences in the merger evolution of two candidate EoSs.
- The numerical relativity software platform Einstein Toolkit is used for the evolution and LORENE for initial data construction. Further, we extract the multipole expanded gravitational wave strain to perform waveform analysis.

Multicomponent relativistic thermalization during big bang nucleosynthesis

(Jan 2017 - present)

Collaborators: Prof. Grant Mathews[1], Dr. Nishanth Sasankan[1], & Prof. Motohiko Kusakabe[2]

[1] University of Notre Dame, [2] Beihang University, Beijing, China.

- We constructed a Monte-Carlo simulation that replicates the thermalization process for a multicomponent mixture in full three-dimensions to achieve the nuclear equilibrium distribution computationally.
- We solved the multicomponent relativistic Boltzmann equation to obtain analytical solution to the equilibrium distribution of species in multicomponent plasmas, and more specifically for nuclei during the big bang nucleosynthesis.
- Publications Phys. Rev. E 103, 032101 (2021), Phys. Rev. D 101, 123532 (2020), JPS Conf. Proc. 31, 011033 (2020), Mem. S.A.It. Vol. 91, 29-34 (2020).
- The simulation codes have been made publicly available on `github.com/AtulKedia93/Multicomponent_relativistic_thermlization`.

Scales to cosmic homogeneity with multiple tracers *(May 2014 - November 2016)*

Advisors: Prof. Subhabrata Majumdar & Dr. Prakash Sarkar

Tata Institute of Fundamental Research, Mumbai, India

- We performed multifractal analysis of multiple tracers of the cosmos namely main galaxy, LRG and quasar samples to test cosmic homogeneity and to identify the scale of transition to homogeneity.
- Our analysis indicates that the SDSS main galaxy sample is homogeneous on a length scales of $80h^{-1}Mpc$ and beyond whereas the SDSS quasar sample and the SDSS LRG sample show transition to homogeneity on an even larger length scales at $\sim 150h^{-1}Mpc$ and $\sim 230h^{-1}Mpc$ respectively.
- ArXiv article 1611.07915 [astro-ph.CO] (2016)

Stability of non-relativistic magnetized astrophysical jets *(Summer 2015)*

Advisors: Prof. Dinshaw Balsara, Dr. Jinho Kim and Dr. Sudip Garain

University of Notre Dame, United States

- Studied the non-relativistic MagnetoHydrodynamics(MHD) equations and numerically solved them by linearizing for a jet-like structure.
- Jet stability was analysed using different velocity profiles and in both the presence and absence of magnetic field. Jets were assumed to have no net electric current and surface currents.

Research publications

[6] "Conformally flat, quasi-circular numerical simulations of the gravitational wave chirp from binary neutron star merger GW170817", G.J. Mathews, I.S. Suh, N.Q. Lan, A. Kedia, 2103.05082 [gr-qc] (2021)

[5] "Simulations of multicomponent relativistic thermalization", A. Kedia, N. Sasankan, G.J. Mathews, M. Kusakabe, Phys. Rev. E 103, 032101 (2021) [Refereed]

[4] "Analysis of the multicomponent relativistic Boltzmann equation for electron scattering in big bang nucleosynthesis", N. Sasankan, A. Kedia, M. Kusakabe, G.J. Mathews, Phys. Rev. D 101, 123532 (2020) [Refereed]

[3] "Cosmological solutions to the Lithium problem", G.J. Mathews, A. Kedia, N. Sasankan, M. Kusakabe, Y. Luo, T. Kajino, D.G. Yamazaki, T. Makki, M.El Eid, JPS Conf. Proc. 31, 011033 (2020), Mem. S.A.It. Vol. 91, 29-34 (2020) [Refereed]

[2] S.R. Brandt, B. Brendal*, W. E. Gabella*, R. Haas*, B. Karakaş*, A. Kedia*, S.G. Rosofsky*, A.P. Schaffarczyk*, et al. (2020, May 30). The Einstein Toolkit (Version The "Turing" release, ET_2020_05). (*=co-second authors)

[1] "The many scales to cosmic homogeneity: Use of multiple tracers from the SDSS", P. Sarkar, S. Majumdar, B. Pandey, A. Kedia, S. Sarkar, 1611.07915 [astro-ph.CO] (2016)

Talks and Presentations

April 2021 "Binary neutron star mergers and the nuclear equations of state." at APS April Meeting.

April 2021 Poster titled "Monte-Carlo simulations of multi-specie relativistic thermalization for Big bang nucleosynthesis." at APS April Meeting.

November 2020 "Monte-Carlo simulations of multi-specie relativistic thermalization and Analysis of Boltzmann Equation for Big bang nucleosynthesis" at APS-DNP Fall meeting.

October 2020 "Full GR simulations of Neutron star binaries at large separations" at Midwest Relativity Meeting.

September 2020 "Relativistic thermodynamics in Big Bang Nucleosynthesis" at U Notre Dame Astrophysics Seminar.

April 2019 "Relativistic electron scattering and Big Bang Nucleosynthesis" at APS April Meeting.

Dec 2018 Poster titled "Relativistic particle scattering and Big Bang Nucleosynthesis" at College of Science and Engineering - Joint Annual Meeting 2018.

Oct 2018 "Relativistic particle scattering and Big Bang Nucleosynthesis" at the Biophysics group led by Prof. Vural at iCeNSA, University of Notre Dame. **(invited)**

Oct 2018 "Relativistic particle scattering and Big Bang Nucleosynthesis" at Interplay between Particle and Astroparticle physics 2018 hosted by University of Cincinnati.

April 2018 Poster titled "Proton distribution function during Big Bang Nucleosynthesis" at APS April Meeting.

June 2017 "Probing homogeneity of the Cosmos using Quasars" at Fourth Azarquiel School of Astronomy.

Nov 2016 Poster titled "Probing homogeneity of the Cosmos using Quasars" at GPS Annual Conference.

Grants and Scholarships

April 2021 Funding awarded by American Physical Society (APS)-Division of Astrophysics (DAP) to present at APS April meeting ($110).

April 2021 Funding awarded by Graduate Student Union (GSU) of University of Notre Dame to present at APS April meeting ($149).

April 2020 Funding awarded by GSU to attend APS April meeting ($500).

April 2019 Funding awarded by APS-DAP to present at APS April meeting ($500).

April 2019 Funding awarded by GSU to present at APS April meeting ($350).

May 2018 Full funding support from organizers to attend Neutron Star Merger summer school at FRIB, Michigan State University.

April 2018 Funding awarded by APS-Division of Nuclear Physics to present at APS April meeting ($400).

Sept 2017 Full funding support from organizers to attend Midwest Theory Get-Together at Argonne National Laboratory.

July 2017 Partial Funding support from organizers to attend National Nuclear Physics Summer School at University of Colorado Boulder (registration, accommodation, and meals).

June 2017 Partial Funding support from organizers to attend Fourth Azarquiel School of Astronomy, on Nuclear Astrophysics and Astroparticle physics at Sicily, Italy (registration, accommodation, and meals).

October 2014 Full tuition scholarship to attend University of Toronto as a semester exchange for spring 2015($\approx$ $14000).

Teaching Experience

Summer 2019 Instructor of Record for Physics 2 Electromagnetism labs at the Department of Physics and Astronomy, Indiana University South Bend.

April 2021 Delivered a lectures on General Relativity for Prof. Mathews at University of Notre Dame.

Feb 2019 Delivered two lectures on Engineering Physics I for Prof. Howk at University of Notre Dame.

March 2018 Delivered a lecture on Math Methods for Physics II for Prof. Vural at University of Notre Dame.

Jan 2017 Delivered a lecture on Elementary Cosmology for Prof. Jessop at University of Notre Dame.

2016-present Teaching Assistant in the Physics department for:
- Special and General Relativity (spring 19, spring 20, spring 21)
- Graduate Classical Mechanics (fall 18)
- Particles and Cosmology (spring 18)
- Descriptive Astronomy (fall 17)
- Elementary Cosmology (fall 17)
- Physics 1 : Mechanics course Lead tutor (fall 19)
- Physics 1 : Mechanics course tutor (summer 17, 18, spring 20)
- Physics 1 : Mechanics lab for pre-med students (fall 16, spring 18)
- Physics 2 : Electromagnetism course tutor (summer 18, fall 18, spring 19, fall 20), received Course Instructor Feedback composite score of upto 5.0/5.0.
- Physics 2 : Electromagnetism lab for pre-med students (spring 17, summer 17)
- Physics 2 : Electromagnetism lab for engineering students (fall 20)

2015 Teaching Assistant for online course on Engineering physics by IIT Bombay and *Teach 10k Teachers* for physics teachers at engineering colleges in India.

Academic service

2020-present Active member of the Einstein Toolkit community, and contributor to the May 2020 Einstein Toolkit release "Turing" and the upcoming May 2021 release.

2020 Session Chair for the session on "Physics of Neutron Stars and Black Holes" at the Midwest Relativity Meeting 2020.

2020 Core-member of the Local Organizing Committee for the Midwest Relativity Meeting 2020.

2019-20 Physics Department Representative at the Graduate Student Union, University of Notre Dame.

2017-18 Graduate International Students committee member at the Physics Department, University of Notre Dame.

March 2017, 2019 Judge for high school and elementary school students' physics projects at the Northern Indiana Regional Science & Engineering Fair(NIRSEF).

2016-18 Volunteer for Our Universe Revealed events and Stargazing events at the University of Notre Dame.

Workshops and Conferences attended

September 2020 ICERM : Advances and Challenges in Computational Relativity (Virtual).

August 2020 North American Einstein Toolkit Workshop (Virtual).

July 2020 FRIB Theory Alliance Summer school: Dense matter in Astrophysics (Virtual).

May 2020 LIGO - Virgo Collaboration Gravitational Wave Open Data Workshop 3 (Virtual).

October 2019 Midwest Relativity Meeting at GVSU, Grand Rapids, Michigan.

June 2019 Einstein Toolkit North American Workshop at RIT, Rochester, NY.

May 2018 Neutron Star Merger summer school at FRIB, Michigan State University with funding support from organizers.

Sept 2017 Midwest Theory Get-Together at Argonne National Laboratory.

Sept 2017 Chemical Evolution of the Universe, GMT community science meeting at Tarrytown, New York.

July 2017 National Nuclear Physics Summer School at University of Colorado Boulder.

July 2017 ICTP-SAIFR School on Open Problems in Cosmology at Sao Paulo, Brazil. (Did not attend)

Skill Set

Programming Languages :- Python, C, C++, and Arduino.

Software Packages :- Einstein Toolkit, LORENE, MATLAB, Mathematica, and LaTeX.

Operating Systems :- Windows and Ubuntu(Linux).

Languages :- Fluent in English and Hindi. Working knowledge of French, German, and Bengali.

Advisors

Prof. Grant Mathews
Professor of Physics, Director of CANDU, University of Notre Dame, USA.
Advisor for M.S. and Ph.D.
Contact - gmathews@nd.edu
Webpage - physics.nd.edu/people/faculty/grant-j-mathews/

Prof. Subhabrata Majumdar
Professor of Theoretical Physics, Tata Institute of Fundamental Research, India.
Advisor for Bachelors thesis
Contact - subha@tifr.res.in
Webpage - theory.tifr.res.in/pheno/people.html