Atul Kedia

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Current Research

My research interests are in theoretical astrophysics and cosmology. I am working with Prof. Grant Mathews and we are currently investigating the effect of electron and photon energy distribution on proton energy distribution during the big bang nucleosynthesis. We built a relativistic thermalization simulation for protons in electron background(Photon background to be added). The relativistic correction to proton energy distribution function changes the reaction rates and hence abundances of light nuclei produced from BBN chain.

Education

2022 **Graduate studies**, *University of Notre Dame*, Physics.

2016 **Graduation**, *Indian Institute of Technology Bombay*, Engineering Physics with Honors in Physics.

2015 **Exchange Semester**, *University of Toronto*, Physics, Spring 2015.

Research Experience

Relativistic electron scattering and Big Bang Nucleosynthesis *(Jan 2017 - present)*

Advisor: Prof. Grant Mathews

University of Notre Dame

- Abstract: Big bang nucleosynthesis (BBN) is a valuable tool to constrain the physics of the early universe. An assumption for calculating abundances of nuclei during BBN is that they obey Maxwell-Boltzmann (MB) statistics. This assumption is shown to be questionable based upon a numerical simulation of the response of nuclei to the background thermal plasma. We show that a nucleus interacts with $e_+ - e_-$ much more than other particles. The $e_+ - e_-$ pairs are mildly relativistic during BBN and hence obey relativistic Fermi-Dirac distribution. As a way to interpret the numerical results we have constructed an analytic Langevin model for the Brownian motion of heavy particle(nuclei) in the background plasma. By accounting for the recoil momentum distribution we obtain a modified MB distribution for nuclei, altered only by a factor related to the recoil momentum. When this modified MB distribution is employed for BBN calculations, the light-element abundances are altered. Unfortunately, this increases the discrepancies between BBN and observed primordial light-element abundances possibly suggesting the need for new physics.
- ArXiv article arXiv:1810.05976 [astro-ph.CO]

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

Advisors: Prof. Subhabrata Majumdar & Dr. Prakash Sarkar

Tata Institute of Fundamental Research, India

- Abstract: We carry out multifractal analyses of multiple tracers namely the main galaxy sample, the LRG sample and the quasar sample from the SDSS to test the assumption of cosmic homogeneity and identify the scale of transition to homogeneity, if any. We consider the behavior of the scaled number counts and the scaling relations of different moments of the galaxy number counts in spheres of varying radius R to calculate the spectrum of the Minkowski-Bouligand general dimension $D_q(R)$ for $-4 \leq q \leq 4$. The present analysis provides us the opportunity to study the spectrum of the generalized dimension $D_q(R)$ for multiple tracers of the cosmic density field over a wide range of length scales and allows us to confidently test the validity of the assumption of cosmic 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. These differences in the scale of homogeneity arise due to the effective mass and redshift scales probed by the different tracers in a Universe where structures form hierarchically. Our results reaffirm the validity of cosmic homogeneity on large scales irrespective of the tracers used and strengthens the foundations of the Standard Model of Cosmology.
- ArXiv article arXiv:1611.07915 [astro-ph.CO]

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. Codes were developed on Mathematica with a colleague.

Conferences and Summer schools attended

April 2019 APS April Meeting at Denver, Colorado. Travel supported by APS-DAP travel grant and GSU-Conference Presentation Grant.

Oct 2018 Interplay between Particle and Astroparticle physics (IPA) 2018 at Cincinnati, Ohio.

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

April 2018 APS April Meeting at Columbus, Ohio. Travel supported by APS-DNP Student travel grant.

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

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 with partial funding support.

July 2017 Invited for ICTP-SAIFR School on Open Problems in Cosmology at Sao Paulo, Brazil.

June 2017 Fourth Azarquiel School of Astronomy, on Nuclear Astrophysics and Astroparticle physics at Sicily, Italy with partial funding support.

Nov 2016 GPS Annual Conference at University of Notre Dame.

Talks and Presentations

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

Dec 2018 Poster title "Relativistic particle scattering and Big Bang Nucleosynthesis" at COSE-JAM 2018.

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

Oct 2018 "Relativistic particle scattering and Big Bang Nucleosynthesis" at IPA 2018.

April 2018 Poster title "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 title "Probing homogeneity of the Cosmos using Quasars" at GPS Annual Conference.

Teaching Experience

Summer 2019 Adjunct Faculty at Indiana University South Bend, teaching Physics 2 labs.

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

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

Jan 2017 Lectured a class on Elementary Cosmology for Prof. Jessop at University of Notre Dame.

2016-present Teaching Assistant for physics 1 lab for pre-med students (fall 16, spring 18), physics 2 lab for pre-med students (spring 17, summer 17), physics 1 course tutor (summer 17, 18), physics 2 course tutor (summer 18, fall 18, spring 19), Descriptive Astronomy and Elementary Cosmology (fall 17), Particles and Cosmology (spring 18), Graduate Classical Mechanics (fall 18), and Special and General Relativity (spring 19).

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

University service

2017-18 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 Northern Indiana Regional Science & Engineering Fair(NIRSEF).

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

Skill Set

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

Software Packages :- 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.
Webpage - physics.nd.edu/people/faculty/grant-j-mathews/
Contact - gmathews@nd.edu

Prof. Subhabrata Majumdar
Professor of Theoretical Physics, Tata Institute of Fundamental Research, India.
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