Atul Kedia

Graduate Physics student

University of Notre Dame

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Research Interest

My research interests are in theoretical astrophysics and cosmology. I am currently researching on the effect of primordial magnetic field on big bang nucleosynthesis, in particular that of lithium, with Prof. Grant Mathews at University of Notre Dame. I am also interested in studying the large-scale structure of the universe, the dynamics of astronomical objects and the role of dark matter in it.

Education

2022   **Graduate studies**, *University of Notre Dame*, Physics, *GPA - 3.58/4.0*.

2016   **Graduation**, *Indian Institute of Technology Bombay*, Engineering Physics with Honors in Physics, *CPI − 7.44/10.0*.

2015   **Exchange Semester**, *University of Toronto*, Physics, *GPA − 3.2/4.0*.
Spring semester of 2015.

2012   **Intermediate/+2**, *Maharashtra State Board*, Science, 80.50 %.

2010   **Matriculation**, *Indian Certificate of Secondary Education*, 92.28 %.

Research Experience

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

Advisor: Prof. Grant Mathews

University of Notre Dame

- We studied nuclear thermalization process during Big Bang Nucleosynthesis(BBN) in order to understand whether the current assumption of Maxwell-Boltzmann(MB) distribution used in calculating nucleic reaction rates is correct.
- For this we built a relativistic thermalization simulator with an environment similar to those during BBN. We observed that since electrons reaction rate outnumbers baryon and photon reaction rate by many orders of magnitude, the thermalization process is dominated by e^+e^- Coulomb scatterings. And electrons are relativistic during BBN temperatures and follow the relativistic fermi-dirac statistics(Maxwell-Juttner distribution). Due to these two, the nuclear velocity distributions they cause are different from the classical MB distribution.
- We showed that this alters the reaction rates between nuclei significantly, and hence, the primordial light-element abundances.
- Presented poster in 2018 APS April Meeting.
- Oral presentation at IPA 2018 at Cincinnati, Ohio.
- Paper being reviewed by Physical Review Letters.

Scale of Cosmic homogeneity using Quasars   *(May 2014 - November 2016)*

Advisors: Prof. Subhabrata Majumdar & Dr. Prakash Sarkar

Tata Institute of Fundamental Research & Indian Institute of Technology Bombay

- Using SDSS-DR10 data for quasars I found out that the universe is consistent with the F-L-R-W metric and obeys the Cosmological Principle, i.e. the universe is homogeneous on a large enough length scale and importantly found the length-scale beyond which the universe is homogeneous.
- The project involves going through various data correction techniques like K-Correction of magnitudes, methods of finding volume limited sample and finding comoving distances. The final calculation of length scale was made using certain fractal dimension definition. Length scale calculation using number counts remains to be performed. Codes developed on MATLAB.
- Presented a poster in the GPS Annual Conference 2016 at University of Notre Dame. Gave a talk in the Fourth Azarquiel School of Astronomy, Italy.
- ArXiv article [arXiv:1611.07915 [astro-ph.CO]](arXiv:1611.07915)

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.

Course Projects

Supermassive Black hole formation simulations (February-April 2016)

Advisors: Prof. Vikram Rentala

Indian Institute of Technology Bombay

Reviewed literature on formation of massive and super-massive black holes. Simulate the formation of massive black holes(SMBH) from gas clouds by mergers of many stellar mass black holes as seeds. Successfully simulated their evolution over time to form MBH. Python package AMUSE was used. Project report can be availed upon request.

Hall Effect Experiment (February-April 2015)

Advisors: Prof. Stephen Morris and Prof. David Bailey

University of Toronto

Found out the hall coefficients for certain N-type, P-type and un-doped Germanium and Silicon semiconductors using the Van der Pauw method. The majority carrier's sheet density, mobility and the band gap for the laminar semiconductors was also found using this technique. Experiment report can be availed upon request.

The Coffee-Ring Effect (August 2013)

Advisor: Prof. Punit Parmananda

Indian Institute of Technology Bombay

- Studied research papers on the non-linearity of Contact Line Formation, Colloid Deposition, Pattern Formation, dependence of patterns formed on Colloid size, shape and certain other parameters, and the Mathematical Structure used in simulate them.
- Experimented the dependence of Colloidal Deposition on concentration and purity, and presented (in a group of four) the four research papers.

Magnetic Field Detection and Controlling (September-November 2014)

Advisor: Prof. Pradeep Sarin & Prof. Tapanendu Kundu

Indian Institute of Technology Bombay

Built a device to measure the geo-magnetic field magnitude and direction in the horizontal plain and to create a field free environment. After measuring through a feedback from Arduino I, in a team of four, tried to control the ambient field using the field generating components; this is an essential requirement of many physical experiments. Project report can be availed upon request.

Polarization of Light *(September 2013)*

Advisor: Prof. Parinda Vasa

Indian Institute of Technology Bombay

In a group of five, simulated various lissajous figures observed in polarized light by making an electrical circuit of active and passive components.

Space Odyssey Program *(October-November 2012)*

Advisor: Prof. Abhiram Ranade

Indian Institute of Technology Bombay

Developed a program in C++ in a group of three to simulate a single-player game.
The programming saw extensive use of classes, functions, loops, inheritance and other aspects of C++ programming.

Scholastic Achievements

2015 Studied at the **University of Toronto**, Canada for a semester under the faculty of Arts and Science as one of the two exchange students from IIT Bombay.

2015 Awarded an A+ grade in courses on Groups & Symmetries and Intro to Biological Physics.

2012 Secured an **All India Rank 673** in IIT-Joint Entrance Exam 2012 out of around 500,000 students.

2012 Secured an **All India Rank 842** in All India Engineering Entrance Exam 2012 out of around 1.2 Million students.

2011 Qualified National Standard Examination in Physics (NSEP) 2011, being in the **All India top 1%** among 43,000 students, and appeared for **Indian National Physics Olympiad** (INPhO) 2012 conducted by Homi Bhabha Centre for Science Education (HBCSE).

Standardized test scores

GRE Physics: 990/990.
GRE General: 320/340 (Verbal: 153/170, Quantitative: 167/170 & AWA: 3/6).
TOEFL: 103/120 (Reading: 22, Listening: 29, Speaking: 24 & Writing: 28).

Conferences attended and Work Experience

October 2018 Interplay between Particle and Astroparticle physics at Cincinnati, Ohio.

May 2018 Attended Neutron Star Merger summer school at FRIB, Michigan State University.

April 2018 Attended APS April meeting at Columbus, Ohio and presented poster titled "Proton distribution function during Big Bang Nucleosynthesis". Travel supported by APS-DNP Student travel grant.

September 2017 Attended the Midwest Theory Get-Together at Argonne National Laboratory with partial funding support.

September 2017 Attended the Chemical Evolution of the Universe, the fifth annual GMT community science meeting at Tarrytown, New York.

July 2017 Attended the National Nuclear Physics Summer School at University of Colorado Boulder with partial funding support.

July 2017	Invited to attend the ICTP-SAIFR School on Open Problems in Cosmology at Sao Paulo, Brazil.
June 2017	Attended the Fourth Azarquiel School of Astronomy, on Nuclear Astrophysics and Astroparticle physics at Sicily, Italy with partial funding support.
November 2016	Attended the GPS Annual Conference at University of Notre Dame.
October 18	Gave a talk at Prof. Vural's (Biophysics) group on 'Relativistic electron scattering and Big Bang Nucleosynthesis'.
September 18	1 minute talk at the Astrophysics seminar, Physics department, ND.
March 2018	Lectured a class on Math Methods for Physics II for Dr. Vural at University of Notre Dame.
January 2017	Lectured a class on Elementary Cosmology for Dr. Jessop at University of Notre Dame.
March 2017	Judge for Northern Indiana Regional Science & Engineering Fair(NIRSEF) 2017. Judged high school students' physics project work.
2016	Volunteer for Our Universe Revealed events at the University of Notre Dame.
2016-present	Teaching Assistant for Physics I lab for pre-med students(fall '16) and Physics II lab for pre-med students(spring '16), Physics I course tutor(summer '17), Physics II lab(summer '17), and Descriptive Astronomy course TA.
2015	Teaching Assistant for an online course on Engineering Physics run by IIT Bombay and *Teach 10k Teachers* for physics teachers at engineering colleges in India.

Relevant Courses

Physics	Quantum Mechanics I, II, & III, General Relativity, Groups & Symmetries, Basic Statistical Mechanics, Intro to Nuclear & Particle Physics, Intro to Atomic and Molecular Physics, Continuum Mechanics, Non-Linear Dynamics, Intro to Condensed Matter Physics, Intro to Biological Physics, Advanced Physics Laboratory, Astrophysics and Electromagnetic Theory.
Others	Complex Analysis, Real Analysis, Differential equations I & II and Computational Fluid Dynamics and Heat Transfer.

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. Good working knowledge of French and German.

Extra-curricular Activities

Sports: I am a big fan of football(soccer) and enjoy playing as well as watching it. I have played at IIT Bombay General Competition and have played and won many intra hostel football competitions. I also enjoy ice-skating and playing badminton, squash, table-tennis and pool at my leisure time.

Music: I am a am an amateur guitarist and I am a fan of rock and metal music and enjoy listening them in my leisure time.

Hiking: I enjoy hiking and exploring new places, and have been to some national parks in India, United States and Canada. I also enjoy trekking and have had the opportunity to trek at Kalsubai peak and Triund peak (India), Great Smoky Mountain and Chautauqua park (USA), Blue Mountains (Canada), and Mt. Etna (Italy).

Geography: I am a Geography nerd and have a particular taste for learning how geographical factors influences a country's economy.

Reading: I developed an interest in reading during my undergraduate years with Sir Arthur Conan Doyle's Sherlock Holmes series and Dan Brown's books being my favourites.

Dancing: I am also fond of dancing and am a beginner level Salsa dancer.

References

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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Prof. Anton Zilman
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