

Spectrum

SCHOOL OF PHYSICAL SCIENCES, IIT MANDI
NEWS VOLUME I JULY, 2023

Editors: Nirmalya Kajuri and Ajay Soni

A YEAR OF MILESTONES



It is with great pleasure that I reach out to you through the first newsletter of the School of Physical Sciences to share some exciting updates.

Over the past months, our School has been buzzing with numerous achievements and milestones. Our faculty members have been actively involved in cutting-edge research, pushing the boundaries of knowledge in various subfields of physics. Their contributions to scientific journals, conferences, and collaborative projects have gained international recognition and cemented our reputation as a leading institution in the field.

Our students have been the driving force behind our success. I am delighted to witness their enthusiasm for physics and their remarkable achievements both inside and outside the classroom. From research projects to national and international competitions, our students continue to demonstrate their intellectual prowess and commitment to excellence.

We have organized several seminars, workshops, and guest lectures, inviting

renowned scientists to share their knowledge with our students and faculty.

We are constantly striving to enhance our educational programs and provide our students with the best possible learning experiences. A very strong high-energy physics group led by young faculty members has recently been started. We are in the process of establishing a laboratory for Quantum Sciences and Technology in addition to existing state-of-the-art laboratories. Our commitment is to nurturing critical thinking, problem-solving skills, and a deep appreciation for the beauty of physics.

Finally, I would like to express my gratitude to

Message from the Chairperson

the entire faculty and staff of our School for their hard work, dedication, and unwavering support. It is through their collective efforts that we have been able to achieve remarkable heights.

Let us continue to explore the wonders of the universe together, inspire each other, and make ground-breaking discoveries that will shape the future of physics.

Suman Kalyan Pal

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HIGHLIGHTS OF THE YEAR 2022-23

Notable Publications

Rasheed Shaik, **Hari R. Varma** et al, Plasmonic Resonant Intercluster Coulombic Decay, **Phys. Rev. Lett.** 130, 233201(2023)

S. Bresolin, **Arko Roy**, G. Ferrari et al, Oscillating Solitons and AC Josephson Effect in Ferromagnetic Bose-Bose Mixtures, **Phys. Rev. Lett.** 130, 220403 (2023).

P. Acharyya, T. Ghosh, K. Pal, K.S. Rana, M. Dutta, D. Swain, M. Etter, **Ajay Soni**, U.V. Waghmare, and K. Biswas, Glassy Thermal Conductivity in Cs₃Bi₂I₆Cl₃ Single Crystal, **Nature Communications** 13, 5053 (2022). (Among top 25 Nature Communications Physics Articles of 2022.)

Projects

Suman Kalyan Pal, Chandra Shekhar Yadav and Hari Varma were awarded SERB Core Research Grants.

.Harsh Soni, Arko Roy and Nirmalya Kajuri were awarded SERB Start up Research Grants.

Honors

Ajay Soni was elected as a senior member of IEEE and as a member of Royal Society of Chemistry.

Hari Varma was appointed

as associate editor of Indian Association for Physics Teachers (IAPT) and guest editor of special issue of "Photon and Particle Impact Spectroscopy and Dynamics of Atoms, Molecules, and Clusters."

Patents

"Biomass compact Briquette fuel and its preparation method" patent filed by **Arti Kashyap** and Pawan Tiwari. Patent No: 201811000279

Awards

Ph.D scholar **Niraj Singh** won the best thesis award in SODH 2023.

Ph.D scholar **Abhishek Sharma** was awarded PMRF.

Ph.D Scholar **Swati Pathak** won Best poster award at CMDAYS 2022 NIT Nagaland.

Postdoctoral Sojourns

Ruchika Mahajan of **Arti Kashyap's** group joined SUNCAT center in Stanford, USA, as a postdoc.

Niraj K Singh of **Ajay Soni's** group joined the University of Linkoping, Sweden.

Shailja Sharma from **CS Yadav's** group joined IFW Dresden, Germany.

Sheetal from **CS Yadav's** group joined as

GNeuS/Marie Curie Fellow at Julich Neutron Center, Julich, Germany

Paromita Dutta of **Sudhir Kumar Pandey's** group joined University of Minnesota, USA.

Antik Sihi of **Sudhir Kumar Pandey's** group joined Trinity College Dublin, Ireland.

Shamim Sk of **Sudhir Kumar Pandey's** group joined the National Institute for Materials Science, Japan.

Karan Singh of **Kaustav Mukherjee's** group joined Polish Academy of Sciences, Poland.

Kavita Yadav of **Kaustav Mukherjee's** group joined Toyota Technological Institute, Japan.

Deepu Kumar of **Pradeep Kumar's** group has joined Sungkyunkwan University, Seoul, South Korea.

Priyamedha Sharma from **Bindu Radhamany's** group joined IIT Bombay.

Rajeev Ray of **Suman Kalyan Pal's** group, joined IIT Ropar.

Conferences

Hot QCD matter conference, May 2022

Out of Equilibrium:

Non-Equilibrium Physics from Cond-Matt to Cosmology, June 2022

Deliberations in Atomic, Molecular, Cluster, and Optical Sciences - 2 (DAMCOS-2), June 2022

Shivalik Hepcats meeting on Cosmology, Astrophysics and High Energy Physics, January 2023

One day workshop in Physics on the occasion of National Science Day, February 2023

Outreach Activities

Teachers training program organized by IIT Mandi and SCERT Delhi, Physics chapter coordinated by **Bindu Radhamany**, lectures by SPS faculty members, March, 2023

"Importance of science and Scientific Methodology," interactive session by **Ajay Soni** for the DST Vigan Jyoti Program for Girls, held at JNV Pandoh, Mandi March, 2023.

Nirmalya Kajuri published popular articles in The Hindu, Indian Express and The Wire Science.

Krishna Mohan Parattu is a member of the core committee of Kerala Theoretical Physics Initiative.

Selected Publications

D. Ranaut, M. Rani, and **K. Mukherjee**, Phys. Rev. B 107, 214413 (2023)

SK Hazra, PK Pathak, TN Dey, Physical Review B 107 (23), 235409

K. Singh, D. Ranaut, **G. Sharma**, and **K. Mukherjee**, New J. Phys. 24, 073037 (2022)

K. Yadav and **K. Mukherjee** J. Phys. Condens. Matter 35, 275601 (2023)

Gurpreet Kaur and **K. Mukherjee** J. Phys. Condens. Matter 34, 415802 (2022)

A Ahmad, KV Raman, S Tewari, **G Sharma** Physical Review B 107 (14), 144206 (2023)

G Sharma, S Nandy, KV Raman, S Tewari Physical Review B 107 (11), 115161

D. Rawat, A. Singh, Niraj K. Singh and **A. Soni**, Phys Rev B 197, 155203 (2023)

P. Acharyya, K. Pal, Abdul Ahad, D. Sarkar, K.S. Rana, M. Dutta, **A. Soni**, U.V. Waghmare and K. Biswas, Advanced Functional Materials 2304607 (2023)

J. Brar, S. Singh, K. Kuga, P. Sharma, Bharath M, T. Takeuchi and **R. Bindu** J.Phys: Condens. Matter 35 195402 (2023)

S. Pathak, S. Singh, S. Khalid, K. Kuga, T. Takeuchi and **R. Bindu** J.Phys: Condens. Matter (accepted)

A. Soni, D. Kushavah, L. Lu, W.H. Chang, **S.K. Pal**, J. Phys. Chem. Lett. 2023, 14, 2965–2972.

H. Soni, Phys Rev E 107 (5), 055104 (2023)

H. Soni, Phys. Rev. E 107 (1), 014111

H. Soni, Physical Review Fluids 8, 044201(2023)

V. Kumar, D. Kumar, B. Singh, Y. Shemerliuk, M.Behnami, B. Büchner, S. Aswartham, and **P. Kumar**, Phys. Rev. B 107, 094417 (2023)

S. Sharma, Shiv Kumar, G.C. Tewari, **G. Sharma**, E.K. Schwier, Kenya Shimada, A. Taraphder, and **C.S. Yadav** Physical Review B 105, 115120 (2022)

Sheetal, A. Elghandour, R. Klingeler, and **C.S. Yadav** Journal of Physics: Condensed Matter, 34, 245801 (2022)

A. Thuppilakkadan, S. Banerjee, **H.R. Varma**, Physical Review A 107 (5), 052804 (2023).

D. Dutta, **A. Roy**, K. Saha, Phys. Rev. B 107, 035120 (2023)

A. Roy, M. Ota, F.Dalfovo, A. Recati, Phys. Rev. A 107, 043301 (2023)

P. Banger, P. Kaur, **A. Roy**, S. Gautam, Computer Physics Communications 279, 108442 (2022)

Y. Khatri, V. Atpadkar, A. Agarwal, and **A. Kashyap**, under review in IEEE Transactions on Magnetics

R.N. Raveendran, **K. Parattu**, L. Sriramkumar, Gen.Rel.Grav. 54 (2022)

N. Kajuri, Phys.Lett.B 825, 136877 (2022)

Seminars

Two Hours of Quantum Entanglement

PC Deshmukh (IIT Tirupati):

Why is reality non-local?

Manik Banik (SNBSC): Bell's Theorem - the most profound discovery of science

Heejun Yang (KAIST): Van der Waal's Heterostructures for

Orbital gating in Photo-transistors and electric spectroscopies

Reji Phillip (RRI): Nonlinear Optics: Fundamentals and Applications

Ganpati Ramanath (Renneselaer Polytechnic Institute): Molecularly tailored nanomaterials and interfaces with novel properties

Patrick Das Gupta (Delhi University): Early universe, primordial black holes and generation of matter-antimatter symmetry

Satyaki Kar (AKPC Mahavidyalaya): Quantum Oscillations in topological nodal line semimetals



Group Photo of the participants of the Out of Equilibrium conference (June 2022)



Group Photo of the participants of the Shivalik Hepcats'23 conference (Jan 2023)

SPOTLIGHT: HIGH ENERGY PHYSICS GROUP

Nirmalya Kajuri



When I joined IIT Mandi last winter, I was the only high energy physicist in the School of Physical Sciences. I soon noticed the strong interest among students in particle physics and cosmology. Much as I was pleased, I was also sad that I could not do justice to all the students who requested guidance.

I was elated when four new faculty members joined SPS this year, all in the fields of Particle Physics and

Group Spotlight

Amal Sarkar is an experimental particle physicist exploring nuclear matter under extreme conditions and physics beyond the Standard Model using collider data.

Prabhakar Palni is an experimentalist, his expertise being in particle physics, heavy ion physics and energy collider physics.

Then there's me. I work on holography and Cosmology.

NEW FACULTY MEMBERS



Krishnamohan Parattu

PhD: IUCAA Pune

Research Area:

Gravitation and Cosmology,
Quantum Information,
Mathematical Physics



Amal Sarkar

PhD: IIT Bombay

Research Area:

Experimental High
Energy Physics



Rahul Kothari

PhD: IIT Kanpur

Research Area:

Cosmology



Prabhakar Palni

PhD: University of
New Mexico, USA

Research Area:

Experimental Nuclear
and Particle Physics

Cosmology. Let me introduce them!

Krishna Mohan Parattu is a theorist. Krishna's current research interest is in the interface between cosmology and quantum information theory.

Rahul Kothari is a cosmologist. His interest is more in observational aspects. Rahul is working on "21 cm Cosmology", which opens a window to the early universe.

Our group is a good mix of experts on theory, observations and experiments. We are learning much from each other.

Our group meets every Friday, along with Ph.D and M.Sc students, to read papers and talk physics over snacks (pizza is a common favourite). Ours is a budding group and we are all excited about the future!

TRANSFERRING ENERGY WITH BUCKYBALLS

Hari Varma



Rasheed Shaik (L) and Hari Varma (R)

Our research predicts an efficient transfer of energy from the buckyball that can stimulate “cold” electrons of a sodium cluster caged in it.

Fullerenes, or buckyballs, are fascinating molecules of carbon atoms having near-spherical structures like a soccer ball. The most popular form of fullerene is C_{60} with 60 carbon atoms forming a spherical cage-like shape. However, spherical fullerenes with a varying number of carbon atoms are also abundant.

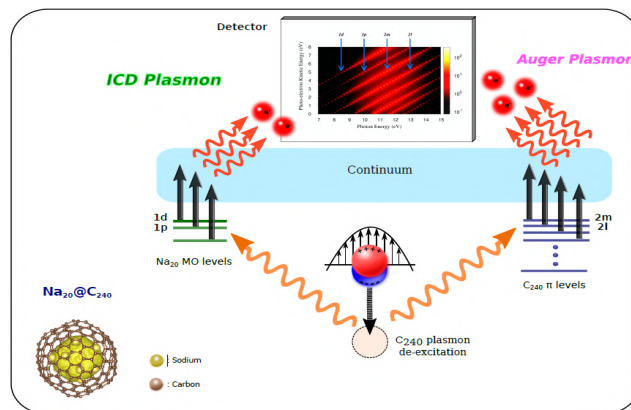
The inside cavity of a fullerene can be doped by atoms, molecules, or clusters. Such doped fullerenes, known as the endohedral fullerenes, have been the subject of intense research since the last few decades. The trapped species inherits certain features of the surrounding cage, especially when such systems are exposed to electromagnetic radiation.

Our recent publication, *Rasheed Shaik, Hari R. Varma et al, Plasmonic Resonant Intercluster Coulombic Decay, Phys. Rev. Lett. 130, 233201(2023)*, focuses on this aspect of interaction with light when a cluster of 20 Na atoms is trapped inside a giant buckyball C_{240} . The oscillating electro-magnetic field of extreme ultraviolet (XUV) light can set up a

group oscillation of quasi-free electrons in a buckyball. This group-motion, known as the collective oscillation, leads to the formation of a giant resonance that can be probed by detecting torrents of electrons leaving the molecule. On the other hand, an XUV light cannot excite the quasi-free electrons in a Na cluster.

Research Focus

However, the situation is different when a Na cluster is trapped inside C_{240} . Our simulations find an efficient transfer of energy from the buckyball to the caged cluster, instigating a group-motion in cluster electrons of Na_{20} as well. As a result, the ionization spectra have a significant contribution from the Na_{20} cluster, as found in the research and schematically shown in the illustration.



The process leads to a new mechanism of large-scale energy transfer between systems that can support group motions. The discovery paves a way to drive and control events at remote sites from a primary energy center.

PHYSICAL REVIEW LETTERS 130, 233201 (2023)

Plasmonic Resonant Intercluster Coulombic Decay

Rasheed Shaik¹, Hari R. Varma^{1,7}, Mohamed El-Amine Madjet^{2,3}, Fulu Zheng², Thomas Frauenheim^{2,4,5} and Himadri S. Chakraborty^{3,1}

Solitons in Ferromagnets

Arko Roy



Periodic motion under the action of a constant force occurs in a very few quantum mechanical systems. More than 20 years ago such an oscillatory behavior was predicted for solitons in ferromagnetic materials,

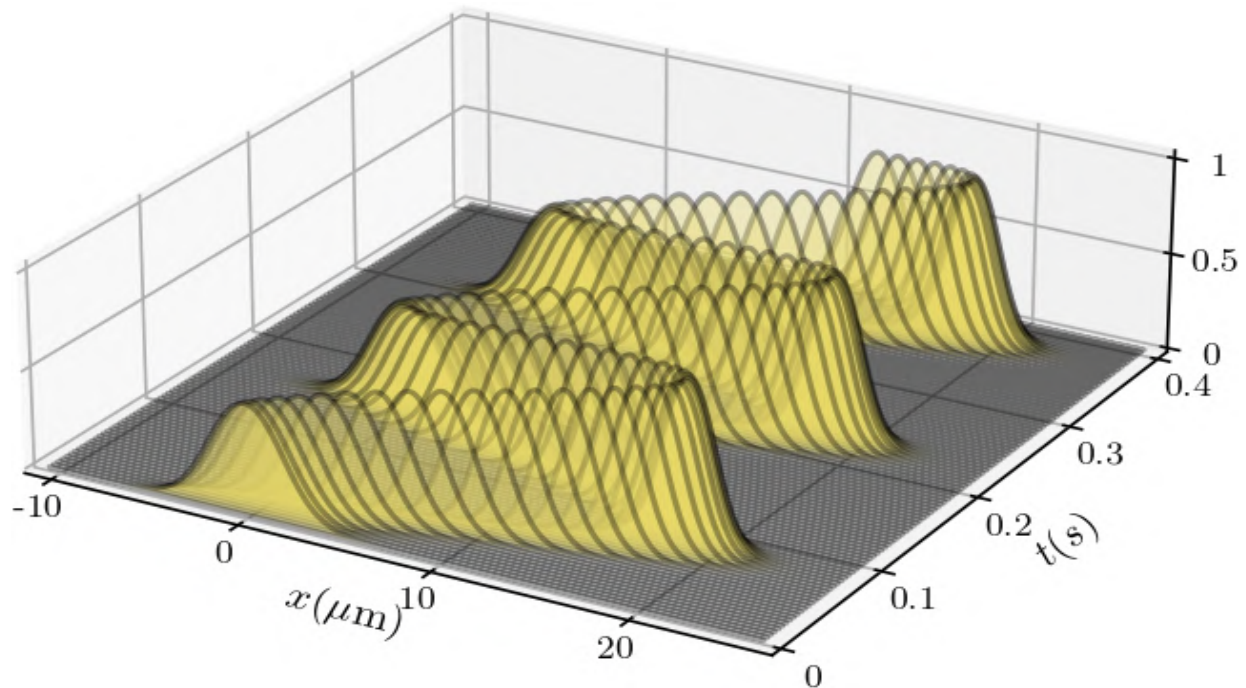
but it has never been observed so far.

In our recent publication, *Sebastiano Bresolin, Arko Roy, Gabriele Ferrari et al, Oscillating Solitons and AC Josephson Effect in Ferromagnetic Bose-Bose Mixtures, Phys. Rev. Lett. 130, 220403 (2023)*, we proposed an implementation of such a system through a mapping onto a two-component Bose-Einstein condensate.

We showed that such a behavior is robust and persists beyond the magnetic analogy and for realistic experimental parameters. Importantly we provide an explanation of the phenomenon in terms of an a.c. Josephson junction.

Research Focus

The figure below shows the numerical results for the evolution under a constant force of a dark-bright soliton in an immiscible mixture condensate of two hyperfine states of Na ($|F = 1, m_F = -1\rangle$ and $|F = 2, m_F = -2\rangle$).



MY JOURNEY IN ENGINEERING PHYSICS

Yuvraj Misra



When I opted for Engineering Physics (EP) at IIT Mandi in 2019, I was confident that I would enjoy working at the intersection of engineering and physics. However, given the diverse nature of EP as a field, I was uncertain about the specific domain of study I would ultimately choose. Fortunately, the EP curriculum was designed to cover a broad range of physics topics, allowing me to explore my interests and discover my niche: Quantum Computing.

Over the past four years, my peers and I have completed a mix of theoretical and practical courses that have provided us with valuable insights and essential skill sets as applied physicists. The theory courses included popular topics such as "Quantum Mechanics and Applications" and "Introduction to General Relativity." The practical courses, such as "Engineering of Instrumentation Practicum" and "Engineering Physics Practicum," gave us the opportunity to work in IIT Mandi's state-of-the-art C4DFED clean room and use high-cost STM/SEM microscopes, among other lab equipment.

The IIT Mandi BTech curriculum, in general, boasts a flexible plan that is conducive to students' personal academic goals. Students can take 22 credits of free electives (FE), which are courses from any discipline of engineering, humanities, or natural sciences, in addition to the mandatory 33 credits of core courses, and 12 credits of discipline electives (DE) that must be relevant to the student's branch. EP students benefit from the interdisciplinary nature of their branch and

can choose courses from the computer science, data science, electrical, mechanical, and mathematics departments to fulfill their DE requirements. Essentially, this allows students to complement their core courses with a unique set of DEs and FEs that align with their curiosity and future academic goals. With proper planning, students can also turn their FEs into minor degrees. Due to my interest in Quantum Computing, I opted for courses in computer science, machine learning, and photonics, which led me to earn two minor degrees: one in Computer Science and the other in Intelligent Systems.

Student Reflections

Moreover, the liberal nature of the EP program provides undergraduates seeking an M.S/Ph.D with the option to specialize in a wide variety of programs, including Physics, Applied/Engineering Physics, Electrical and Computer Engineering, Material Science Engineering, and Computer Science, among others. In order to shape their profiles and meet the admission requirements of these different programs, students should engage in appropriate research projects during their vacations, choose relevant coursework as DEs and FEs, and pursue suitable minor degrees.

Furthermore, students can participate in a semester exchange program (for up to two semesters) at foreign universities that have a Memorandum of Understanding (MoU) with IIT Mandi. Many of these universities are top German institutions, including RWTH Aachen and TU Munich, as well as the Norwegian University of Science and Technology, among others.

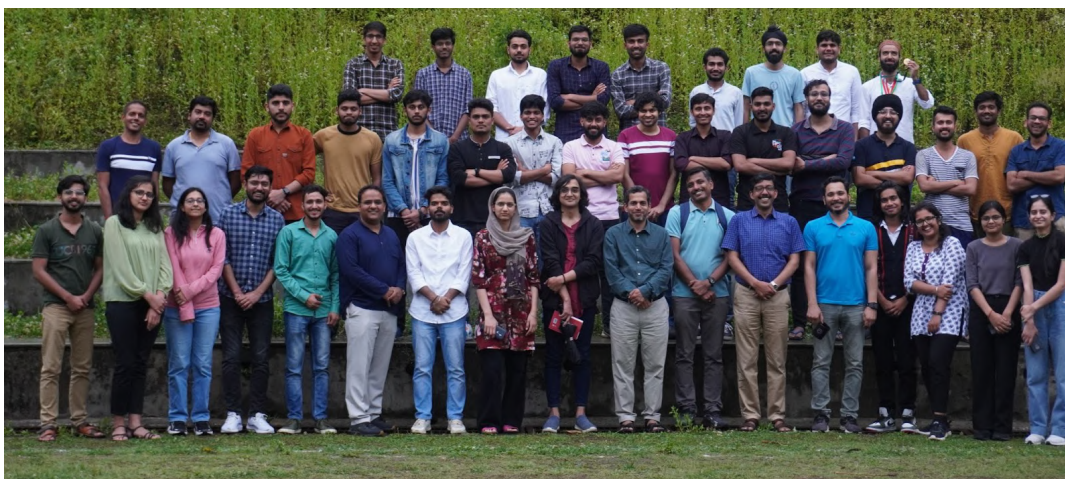
In my personal journey, I undertook research projects with a professor during every vacation starting from the 4th semester. These projects helped me identify topics I liked and disliked, guided me in choosing courses for the upcoming semesters, and provided me with an opportunity to apply what I had learned. Students at IIT Mandi can also engage in projects or research work as part of their curriculum through a 2-month internship, 6-month internship, and a Major Technical Project (only in the final year). The experience I gained from these projects and the BTech EP program at IIT Mandi played a significant role in securing admissions to top US universities for an M.S in Electrical and Computer Engineering.

I received admissions from the University of Michigan, Ann Arbor, and the University of Washington, Seattle, along with fully funded teaching and research assistant scholarships from Purdue University and the University of Illinois,

Urbana-Champaign(UIUC), respectively. Furthermore, a few companies also visited the campus for core Engineering Physics placements, mostly in the areas of quantum computing and quantum communications. I myself received a job offer from LTIMindtree for a quantum computing research position.

If you are considering applying to the EP program at IIT Mandi, I hope this article has provided you with more clarity on whether it would be a good fit for you. Wishing you all the best, and if you would like to get in touch, please feel free to reach me at ashyuvraj@gmail.com.

(Yuvraj Misra is an Engineering Physics batch of 2023 alumni. He is currently pursuing a Ph.D in quantum computing from the University of Urbana-Champaign)



Above: Engineering Physics batch 2023 with faculty after their Farewell event
Below: M.Sc Physcs batch 2023 with faculty after their Farewell event

A DAY OF PHYSICS

On 28 Feb, 2023 School of Physical Sciences conducted a one-day workshop celebrating National Science day. It was a day filled with insightful talks, engaging posters and friendly competition. M.Sc student **Trishu Verma** captured some of the memorable moments from the day.



Director Professor Laxmidhar Behera inaugurating the event



Chief Guest Professor PK Raina (IIT Ropar) giving his talk on the contribution of physics to society



Arko Roy giving a seminar about his research on condensates

Visual Vignettes



Right: PhD Scholar Divya explaining her research on Bismuth compounds



CS Yadav delivering his seminar on frustrated magnetic systems



Students listening intently



PhD Scholar Mansi Rani explaining her poster



Rahul Kothari and MSc student Umashankar Pardhi having a quick discussion



PhD Scholar Siddharth Mithiya receives a Poster award from the school chair Suman Kalyan Pal



Group Photograph of the M.Sc 2023 batch with the faculty and staff members of School of Physical Sciences

Winners of National Science Day Competitions:

Technical Presentations: Divya Rawat, Rasheed Shaik, Dheeraj Ranaut

Posters: Manshi Rani, Ankit Kashyap, Siddhartha Mithiya

Logo design: 1. Mohit Mahajan 2. Mahipal Kumawat 3. Sania Ayoub and Adity

SCHOOL OF PHYSICAL SCIENCES OVERVIEW

List of Faculty Members

- ❖ Ajay Soni
- ❖ Amal Sarkar
- ❖ Arko Roy
- ❖ Arti Kashyap
- ❖ Bindu Radhamany
- ❖ Chandra Sekhar Yadav
- ❖ Gargee Sharma
- ❖ Hari Varma
- ❖ Harsh Soni
- ❖ Kaustav Mukherjee
- ❖ Krishna Mohan Parattu
- ❖ Nirmalya Kajuri
- ❖ Prabhakar Palni
- ❖ Pradeep Kumar
- ❖ Pradyumna Pathak
- ❖ Prasanth P. Jose
- ❖ Rahul Kothari
- ❖ Suman Kalyan Pal(Chair)

List of Staff Members

- ❖ Aditi Thakur
- ❖ Anugraha Rawat
- ❖ Akshay Kapoor
- ❖ Devesh Sharma
- ❖ Mrinal Malhotra

Areas of Research

- ❑ Atomic, Molecular and Optical Physics
- ❑ Condensed Matter Physics
- ❑ Soft Matter Physics
- ❑ High Energy Physics

Programs

- ❑ B. Tech (Engineering Physics)
- ❑ M.Sc (Physics)
- ❑ PhD
- ❑ Integrated PhD
- ❑ Dual degree (M.S+PhD)

Images of Physics Teaching Lab equipments:



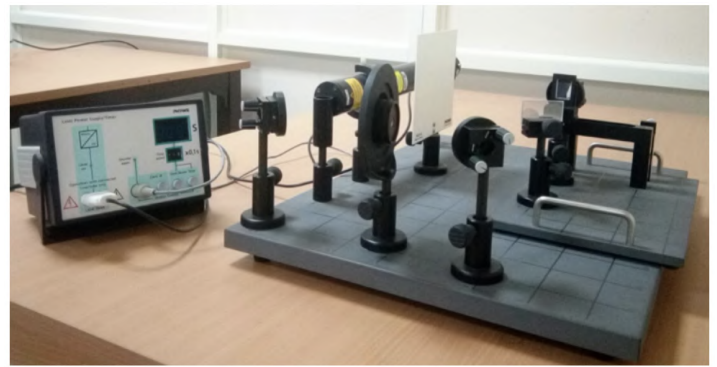
Ultrasonic Diffraction



Zeeman Effect with Electromagnet



Fourier Optics



Fabry Perot Interferometer

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