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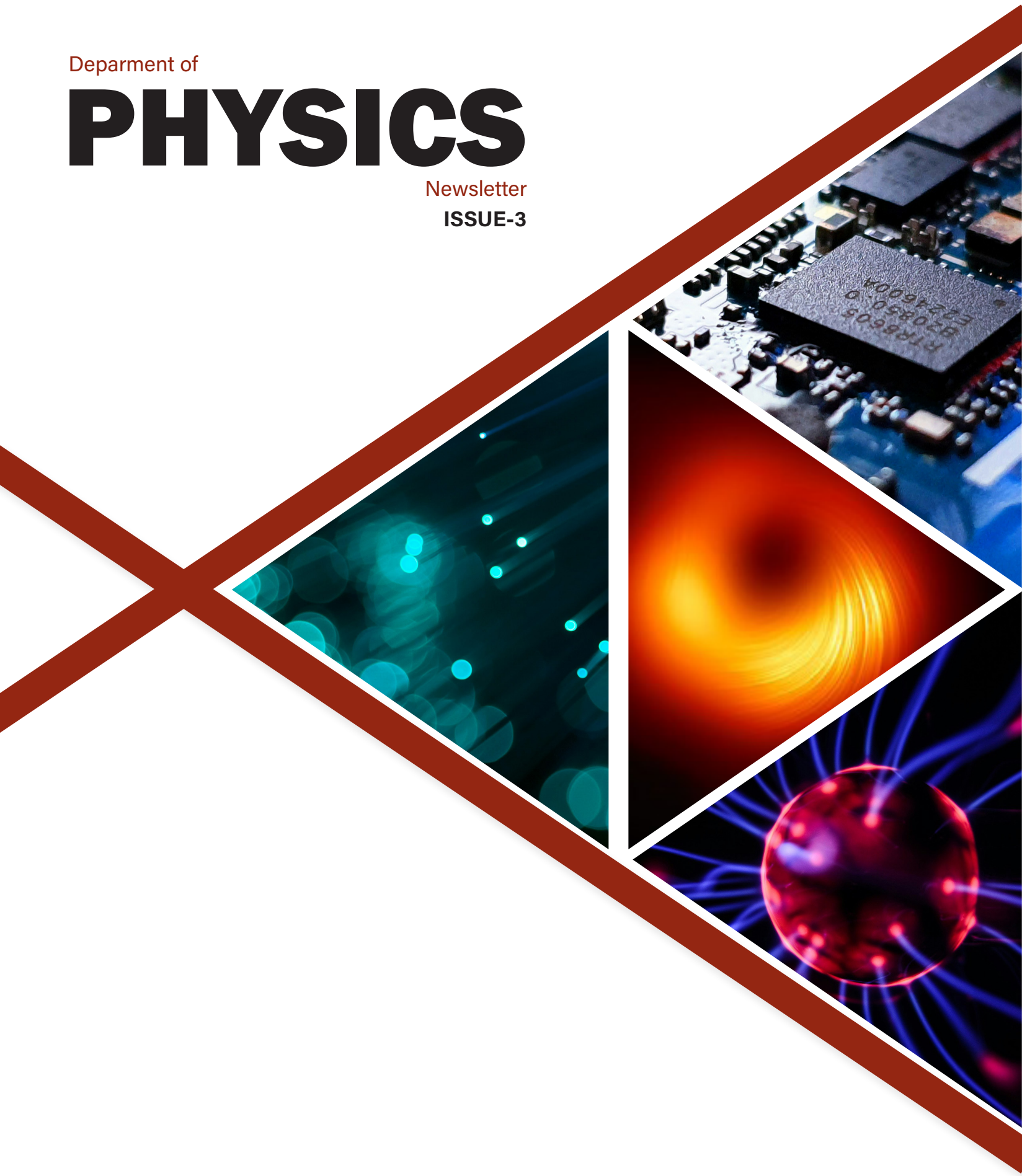
PHYSICS

Newsletter

ISSUE-3



Department of Physics

Vision

The department visualises itself to be a centre of excellence of Physical Sciences.

Mission

- The department endeavors to achieve its set goals through introduction of innovative and intellectually challenging courses.
- The department vows to undertake to strengthen its presence in technological programs offered by the institute to benefit the society.

The Department of Physics, SVNIT Surat, is one of India's leading departments in terms of research, and holds a coveted position in the world. The faculty and students have successfully completed numerousscientific and research projects sponsored by National Scientific Agencies. The Department of Physics has multifaceted roles to play in the institute. It is catering to the needs of the country by creating a scientist pool by conducting innovative five years integrated M.Sc. programs and Ph.D. programs. The department has supervised several students towards their Ph.D. degrees. It offers Ph.D. programs in the areas of Condensed Matter Physics, Material Science, Theoretical Physics, Space Science, and Particle Physics. The Department has well-equipped laboratories attached to different divisions for conducting teaching and research activities.

With immense pleasure, the Department of Physics is glad to announce the commencement of the first batch of B.Tech in Engineering Physics from the academic year 2024-25.

Message from Head of Department

Greetings from the Department of Physics!

With the onset of the new academic year, the exuberance of a new beginning amongst faculty and students at the Department of Physics is higher than ever. I also welcome the new students who have joined the Department Of Physics, as well as returning students eager to catch up with each other and explore new challenges and opportunities, and established faculty invigorated after summer months focused on research. Each academic year brings change, but the sense of revitalization we experience every time is a fundamental constant we look forward to and depend upon.

I feel exhilarated as I look back at the milestones that the Department has been able to achieve in the past academic year, and this newsletter is an opportunity to reflect on our accomplishments and look forward to the upcoming year.

With this newsletter, we look back on the achievements of faculty and students that have added to the pride of our Department. Building on a wave of outstanding new faculty arrivals, our faculty continue to win prestigious awards and fellowships and propel the research prominence of the department.

Message from Faculty Advisors

Dr. Dimple V. Shah,
Associate Professor, Ph. D.

It gives me immense pleasure to introduce the third issue of the annual newsletter of our department. It is indeed a happy moment for me that our beloved students of the Department of Physics have continued this initiative and I congratulate them from the bottom of my heart! The newsletter aims to provide an overview of the seminars, and workshops conducted in the department and activities organised by the student chapter. This issue contains the achievements of our students and highlights the research publications, achievements and activities conducted by the faculty members.

I congratulate all the students and faculty members for their respective achievements. I sincerely hope that the release of our annual newsletter will highlight the summary of the departmental activities at the Institute, national and International levels as well.

Lt. (Dr.) Y. A. Sonvane,
Associate Professor, Ph. D.

I applaud the entire team for bringing out the third issue of our annual newsletter. This issue covers the events conducted by the Department and Physics Club, and various workshops and seminars conducted by the Department of Physics. The newsletter celebrates our student's accomplishments while also highlighting the faculty's research publications and initiatives. This is intended to guide the student community so that they can easily approach the concerned faculty members.

I acknowledge the efforts put forward by the students. I hope this issue will be helpful to all the students and faculty members to stay updated with and get insights into the departmental activities. We happily encourage and welcome feedback from students and faculty members.

Message from Newsletter Team

We are delighted to present the third edition of the Department of Physics Newsletter. In this edition, we have covered the Department, Mission, Vision, Notes from the Head of Department and Faculties, Physics Club activities, Workshops and Seminars conducted by the Department, Faculty Achievements & Publications, Student Achievements, Scholarships, Internships, and Placements.

Another splendid semester, with students from the Department of Physics bringing honours to the institution in every possible way.

We also take pride in the latest addition to our newsletter, "Research Stories", where our students have shared in detail their research experiences as interns and full-time dissertation students at prestigious institutions in India and abroad. They have also taken the time to share how they secured these positions in order to spread more awareness about the various options available to our students if they wish to pursue a similar path. We hope this serves as a guide and inspiration to the present students of our Department, as they embark on their own research journeys.

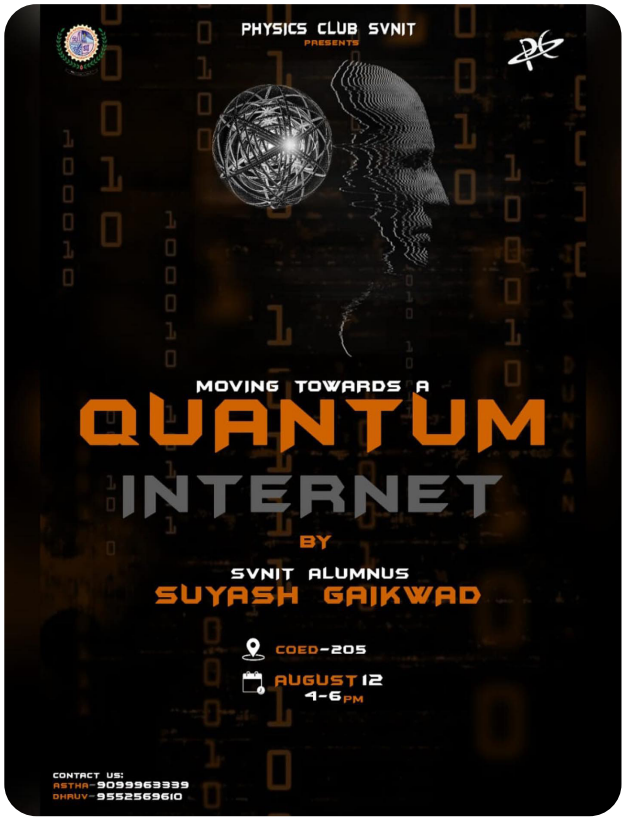
With this newsletter, we aim to apprise the activities in the Department throughout the year. We have also added student achievements and internships sections so anyone can approach and get further information about the work they've done.

Isn't it rightly said, "A flower makes no garland"? Thus, this newsletter is not the outcome of the effort put in by an individual but is the immense effort put forward by Dr Debesh R. Roy, Head of the Department, faculty advisors, and our editorial board. At last, we've mentioned our team, whom we owe an enormous debt of gratitude for their tireless devotion and efforts in continuing to build the legacy of the Department through this newsletter.

With Regards,

Newsletter Team, Department of Physics

A. Events organised by the Physics Club

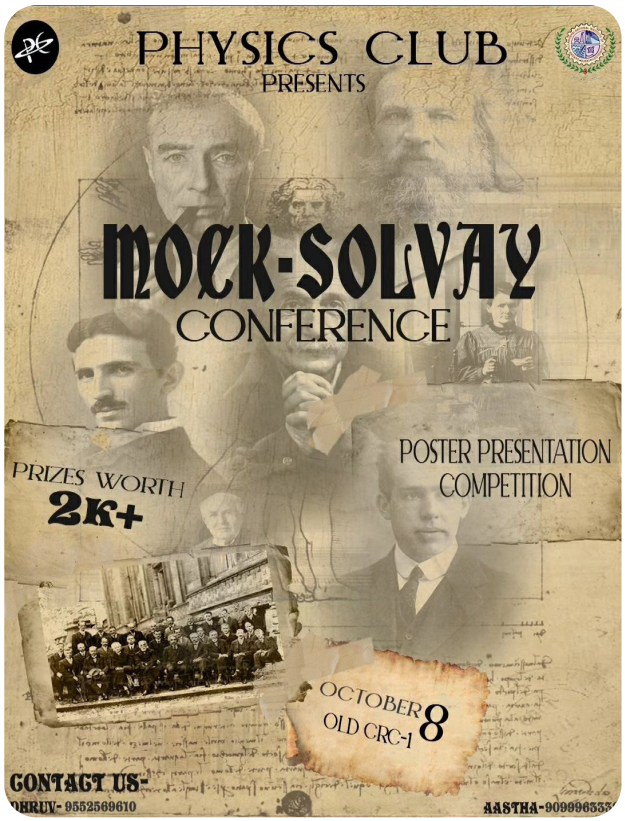


1. Quantum Internet

The Physics Club organised a seminar titled 'Moving towards a Quantum Internet' presented by our alumnus Suyash Gaikwad (Batch of 2023), on 12th August 2023. It was followed by a seminar on research opportunities abroad and proper guidance was provided to those with a heart for physics.

The Talk was based on chip-scale quantum memory utilising silicon nano photonics, and prominently focused on how silicon nanophotonics can be leveraged to create chip-scale quantum memory devices. His insights were drawn from his Master's Thesis work at the Max Planck Institute of Quantum Optics in Germany.

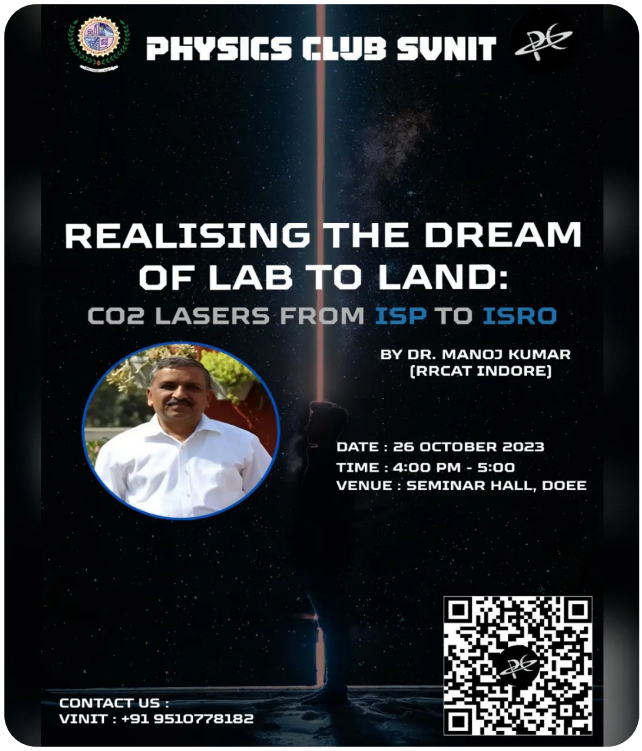
He also presented his valuable views on foreign academic endeavours, including navigating and cultural differences, research collaborations, and funding opportunities. The seminar helped in widening the perception of the students who are aiming to pursue higher education in physics.



2. Mock Solvay Conference

The Mock Solvay Conference was an exciting opportunity for students to explore the deep questions of Physics and dive into the cosmos with a poster quest. Students had the privilege of attending a talk by Dr. Tejinder Pal Singh from TIFR, Mumbai who spoke on the topic: "Dark matter or a new law of gravitation?" This was a golden opportunity for the students to explore ideas and discoveries at one place. Dr. Tejinder Pal Singh discussed the role of Dark Matter in shaping the cosmos, its gravitational effects, and the ongoing efforts to detect and understand this elusive substance.

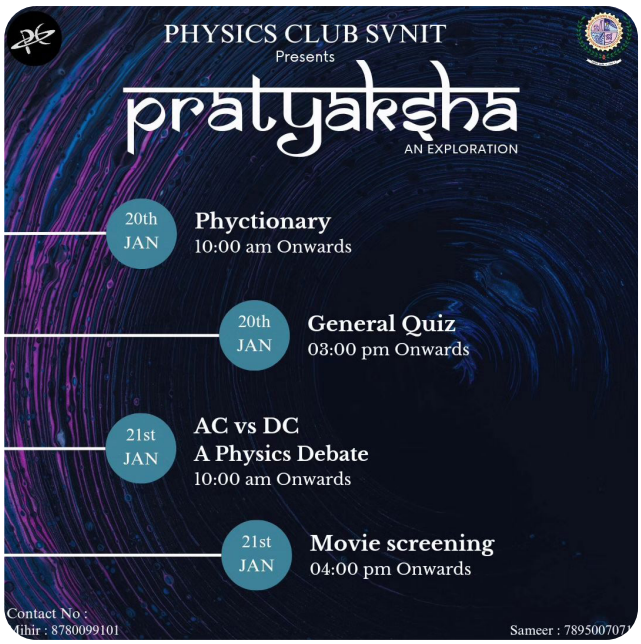
Dr. Singh provided his insights on the questions raised by the students. Also, he challenged conventional notions of gravitation and proposed intriguing alternatives. Thus, an atmosphere similar to a Solvay Conference was made in the seminar.



3. Realising the Dream of Lab to Land: CO2 Lasers from ISP to ISRO

This event was conducted on 26th October 2023.We had the pleasure of hosting our esteemed guest Dr. Manoj Kumar, a renowned physicist from RRCAT, Indore, who shared his remarkable work on laser refurbishment. The presentation highlighted the success story of refurbishing non-functional CO2 lasers at Indian Security Press (ISP) in Nashik and Vikram Sarabhai Space Center (VSSC) in Trivandrum.

Dr. Gupta gave a brief information about the journey of CO2 Lasers-from their inception in the laboratory to their practical applications at ISRO. His style of delivering the ideas was the most influential part of the seminar. He was felicitated by the Physics Club's faculty Coordinators, Dr. Vipul Kheraj and Dr. Vikas Ojha, for his outstanding contribution to the scientific discoveries.



4. Pratyaksh - An Exploration

Pratyaksha is Physics club's flagship event held every year. Last year, it was organised on 20th and 21st January. The event was a combination of 4 activities: Pictionary, Physics Quiz, AC vs DC (Debate Competition) and Sci-fi movie screening.

B. Workshop Organised by Department of Physics - NIT Surat - In Collaboration with BARC

BRNS-IANCAS National Workshop on "Radiochemistry and Applications of Radioisotopes"

The 106th INCAS workshop on 'Radiochemistry and Application of Radioisotopes was conducted at NIT Surat, by the Department of Physics (NIT Surat) in collaboration with Indian Association of Nuclear Chemists and Allied Scientists (IANSAC) c/o Radiochemistry Division BARC Mumbai. During the workshop, a team of renowned women scientists from BARC presented their lectures on nuclear physics, nuclear chemistry, nuclear reactors, production and application of radioisotopes, and health and safety aspects taken into consideration during performing the experiments in such fields of sciences.

The duration of this workshop was 5 days, which began on 8th January 2024 & ended on 12th January 2024. The workshop was prominently for various faculty members engaged in teaching, research scholars from research areas like Nuclear Science and Technology, Chemistry, Physics, Biosciences/ Biotechnologies, Pharmaceutical Environmental Sciences, etc. Applications from many students from various institutions were also invited. To have a thorough grasp of the information and knowledge, each day quizzes were conducted at the end of the lectures, and the winners were felicitated accordingly. At the conclusion of each day, individual discussions were held between participants and the scientists as well.

A. Faculty Achievements

- **Dr. Debesh R. Roy** has featured in the 'World's top 2% scientists' list published by Stanford University, USA & Elsevier in the '2022 citation impact' category, September 2023.
- **Dr. Dipika Patel** has received a CSIR EMR II project grant.
- **Dr. Shail Pandey** has received a CSIR EMR-II project grant.
- **Dr. Yogesh Sonvane** has been appointed as a Guest Editor for a special issue of Modern Physics Letter B Journal.
- **Dr. Vipul Kheraj** has been invited as a Science Communicator and honorary Science Columnist for the popular GSTV publications.
- **Dr. Vipul Kheraj** has been invited as a Guest Editor of Discover Applied Sciences (Springer Nature).
- **Dr. Dimple Shah** has received Design Patent to "Hot plate with Magnetic stirrer for Laboratory use".

B. Student Achievements

- **Sidharth (I19PH043)** has carried out full year Master's dissertation work in the AY 2023-24 at Leibniz Institute for Plasma Science and Technology, Germany, under DAAD-WISE fellowship.
- **Sidharth (I19PH043)** has been offered a PhD position in the Elementary Processes in Gas Discharges group within the Department of Applied Physics & Science Education, Eindhoven University of Technology (TU/e).
- **Hershini Gadaria (I19PH041)** has been offered a PhD position in Physics at Michigan State University, Michigan.
- **Sreejita Das (I19PH017)** had secured a fully-funded internship at the Max Planck Institute for Astronomy, Germany.
- **Sreejita Das (I19PH017)** has been awarded the DAAD Research Grant for Doctoral Programmes in Germany (grant number 57693453), along with additional funding from the European Research Council, to pursue a joint PhD at Ludwig Maximilian University and the European Southern Observatory in Munich, Germany.
- **Adithya A Rao (I19PH001)** has been nominated by DST-GoI and The Council for Lindau Nobel Laureate Meetings to attend the upcoming 73rd Lindau Nobel Laureate Meetings in Physics. The meetings will be held in Lindau, Germany, from 30 June to 5 July 2024.
- **Hetul Sukharamwala (I19PH005)** has been awarded the Engineering Silver Star Graduate Scholarship and MSE Research Scholarship at University of Texas, Arlington, to pursue a Master's of Science degree in Material science and engineering.
- **Kishant Kumar Bhushan (I20PH010)**, has got a SRFP fellowship at Indian Institute of Technology (IIT), Delhi and has secured a summer internship at Plasma Lab at IIT, Delhi on the topic of Non-Compact ECR source based Plasma System. He also got a SURE fellowship at IIT Hyderabad and also got a Summer Internship Programme fellowship at Ahmedabad University.

Achievements

- **Kishant Kumar Bhushan (I20PH010)**, has secured 1st rank in Gujarat State in the National Graduate Physics Examination (NGPE), 2023.
- **Chiranjeet (I20PH045)** was selected and completed the Introductory Summer School in Astronomy & Astrophysics (ISSAA) 2024 at Inter-University Centre for Astronomy & Astrophysics (IUCAA) from May to June 2024.
- **Abhay Karia (I20PH002)** has been awarded with VSP'23 Fellowship at IUCAA, Pune. He has been contributing for the upcoming LIGO-India project while working on LIGO instrumentation at IUCAA.
- **Abhay Karia (I20PH002)** has been awarded with the Future Research Talent Award - 2024 given by the Australian National University. He is contributing to the ground based demonstrator for formation flying PYXIS optical interferometer while working at Research School of Astronomy and Astrophysics, Mt. Stromlo Observatory.
- **Sri Sankaran (I20PH064)** received a grant worth Rs.1.3 Lakh from ASHINE, SVNIT for the "Development of a Standalone System for Combined Van der Pauw Resistivity and Hall Effect Measurements".
- **Abhyuday Verma (I21PH021)**, secured second runner's up position(3rd) in All India Inter-NIT Badminton Tournament at MNIT Jaipur, Rajasthan.
- **Abhyuday Verma (I21PH021)**, selected for Summer Research Internship at Indian Institute of Science Education and Research Bhopal (IISER B) on the topic of "Simulation of Interesting Quantum Phenomena".
- **Sneh Shah (I21PH019)** was one of the 50 students selected from all across India for a week-long Physics training programme at Poornaprajna College (affiliated to Mangalore University), Udupi. The program was conducted by the PTTS (Physics Training and Talent Search) organization from August 21 to 27, 2023.
- **Sneh Shah (I21PH019)** joined CESSI (Center of Excellence in Space Sciences India), IISER Kolkata, as an SRF (Summer Research Fellow) under the supervision of Prof. Dibyendu Nandi. The duration of the internship is from May 25, 2024, to July 19, 2024. The topic of research will be Solar Dynamo Theory and Magnetohydrodynamics.
- **Spandan Biswal (I21PH039)** selected for Summer Research Fellowship Program(SRFP) 2024 , by Indian Academy of Sciences to work at Physical Research Laboratory (PRL) as a summer intern. The topic of research is "Study of Microvariability Phenomena in Blazars".
- **Shivam randive (I22PH019)** has secured a summer internship at IIT Bhilai on "Strain engineering of thin film" and contributing in a paper.
- **Ankush Kumar (I22PH027)** has secured a summer internship at RCI-UBA,SVNIT Surat for the duration of 50 days on the topic "Renewable energy sources".
- **Sujal Vadgave (I22PH004)** has secured a summer internship at IIT Bombay in the field of Quantum Mechanics (Ultrafast Theory) on the topic 'Light Enhanced Non Linear Hall Effect'. He has also received the summer internship offer letter from BARC and IIT Tirupati.
- **Shreya Dave (I23PH003)** has been selected for NIUS (National Initiative on Undergraduate Science) Astronomy programme at HBCSE (Homi Bhabha Centre for Science Education), TIFR (Tata Institute of Fundamental Research).
- **Shouvik Ghosh (I23PH028)** has secured a summer internship in the field of "Optical Physics", at Indian Institute of Technology Tirupati (IIT TIRUPATI).

- **Pradyumna Nimbkar (I23PH012)** secured a summer internship at Indian Institute of Technology, Bhilai based on '2-D materials'.
- **Soumya Sundar Parui (D20PH015)**, research scholar of the department has been awarded a research internship entitled "Fast, Efficient, Cost-Effective: A One-Step Revolution for CsPbBr3 Thin Films" under the INUP program at IIT Madras.
- **Shubhankur Suvansh (D22PH008)** received Best Poster Award for his poster presentation titled, "Numerical Study of Electron Heating and Transport Property in a Co-axial Electron Cyclotron Resonance Plasma Thruster" in the National Conference on Recent Trends in Space Technology (RTST-2024), MNIT Jaipur, 20-21 March, 2024.

C. List of External Sponsored Research Projects during 2023-24

Serial No.	Title of the Project	Sponsoring Authority	PI/Co-PI/Mentor	Grant Sanctioned (Rs.)
1.	Group III-V Inorganic Semiconductor Clusters for Future Nanoelectronics Applications	SERB, India	Dr. D. R. Roy (PI)	33, 67, 513/-
2.	Nanostructured metal oxide-drug assemblies and their interaction mechanism with biomolecules: A joint experimental and first principal investigation for possible therapeutic applications	SERB, India	Dr. D. R. Roy (Mentor) Dr. S. M. Roy (PI, PTSCS, VNSGU)	18, 30, 000/-
3.	Interface engineering of 3D/2D Lead-Free Halide Perovskites Materials for Solar Cells	SERB, India	Dr. Y. A. Sonvane (PI)	30, 00, 000/-
4.	Development of Ink-Printed Flexible Solar Cell with Antimony-based Nanostructured Perovskite using Slot-Die Coating	GUJCOST, India	Dr. V. A. Kheraj (PI)	22, 40, 200/-
5.	Role of rotating magnetic field in the microwave-induced plasma source for clean energy: directed motion and controlled energy distribution of charged particles	CSIR, India	Dr. S. Pandey (PI) Dr. H. Pandey (Co-PI)	25, 00, 000/-
6.	Determination of higher- order deformations of atomic nuclei by quasi- elastic scattering	CSIR, India	Dr. D. Patel (PI)	28, 00, 000/-

Publication in the International Journals

Sr. No.	Authors, Title Of The Paper, Name Of The Journal, Publisher, Volume, Page Nos., Year*
1.	Jaskirat Kaur, S.D. Pathak, **Vikash Kumar Ojha**, Maxim Yu Khlopov, Inflection point of coupled quintessence, Astroparticle Physics, 157, 102926, 2024
2.	Chandan Maity and **Mithun Karmakar**, Wave breaking amplitudes of Langmuir modes in electron-positron-ion dusty plasmas, Phys. Scr. 98, 085601, 2023
3.	Trilokchand L. Kumavat, Radha N Somaiya and **Yogesh Sonvane**, Palladium-decorated SiX (X = N, P, As, Sb, Bi) catalysts for hydrogen evolution, RSC Catalysis Science & Technology, 14, 253 ,2024
4.	Trilokchand L. Kumavat, Radha N Somaiya and **Yogesh Sonvane**, Strain modulated optical properties of MoSi2P4 Monolayer – Insights from DFT, Manuscript Accepted, IOP Physica Scripta, 99 065930, 2024
5.	Neeraj Kumar, Jay Jasani, **Yogesh Sonvane**, JG Korvink, A Sharma, B Sharma, Unfolding the hydrogen gas sensing mechanism across 2D Pnictogen/graphene heterostructure sensors, Sensors and Actuators B: Chemical 399, 134807, 2024
6.	S Singh, **Yogesh Sonvane**, KA Nekrasov, AY Kupryazhkin, PN Gajjar, SK Gupta, A first-principles investigation of defect energetics and diffusion in actinide dioxides, Journal of Nuclear Materials 591, 154901, 2024
7.	P. R. Parmar, S. J. Khengar, **Yogesh Sonvane** and P. B. Thakor, Enhanced photocatalytic performance of a stable type–II PtSe2/GaSe van der Waals heterostructure, Physical Chemistry Chemical Physics, 25, 22258, 2023
8.	P. R. Parmar, S. J. Khengar, Disha Mehta, **Yogesh Sonvane** and P. B. Thakor, Solar energy harvesting by a PtS2/ZrS2 van der Waals heterostructure, New Journal Chemistry, 47, 15162, 2023
9.	C. Bhuptani, D. Patel, **V.K. Ojha**, S. Mukherjee, 14N break-up α emission with 59Co, 93Nb, and 197Au targets at an incident energy of 250 Me, Journal of Radioanalytical and Nuclear Chemistry, 1-6, 2024
10.	Y K Gupta, VB Katariy, GK Prajapati, K Hagino, **D. Patel**, V Ranga, LS Danu, A Pal, BN Joshi, S Dubey, VV Desai, S Panwar, U Garg, N Kumar, S Mukhopadhyay, Pawan Singh, N Sirswal, R Sariyal, I Mazumdar, BV John, Precise determination of quadrupole and hexadecapole deformation parameters of the sd-shell nucleus, 28Si, Physics Letters B, 845, 2023
11.	Ashvin Kanzariya, Shardul Vadalkar, Sourav Kanti Jana,, **L.K. Saini**, Prafulla K. Jha. An ab-initio investigation of transition metal-doped graphene quantum dots for the adsorption of hazardous CO2, H2S, HCN, and CNCl molecules. Journal of Physics and Chemistry of Solids 186, 111799, 2024.
12.	Ashvin Kanzariya, Shardul Vadalkar, **L.K. Saini**, Prafulla K. Jha. Cyclo[16]carbon through the lens of density functional theory: Role of impurity decoration in hydrogen evolution reaction. International Journal of Hydrogen Energy 71, 400–410, 2024
13.	**Lalit K Saini**, Amanjeet Panghal, Sumit Choudhary, Rekha Dhiman, Ranjeet Singh, Balwinder Singh, · Shakuntala Rani, Babita, Arpeeta Kumari, Assessment of surface and mass exhalation rate in soil from Diamond City Surat, Gujrat, India. Journal of Radioanalytical and Nuclear Chemistry. https://doi.org/10.1007/s10967-024-09507-5, 2024
14.	A. Ojha, S. Suvansh, **H. Pandey**, and **Shail Pandey**, "Electron cyclotron resonance (ECR) enhanced diverging magnetic field for controlled particle flux in a microwave-excited plasma column – a numerical investigation", Physica Scripta, IOPScience, 99, 025618, 2024.

15.	A. Ojha, **H. Pandey** and **Shail Pandey**, "Metastable controlled plasma profile in a packed bed microwave plasma reactor", IEEE Transactions on Plasma Science, IEEE, 51, 3510 - 3517, 2023.
16.	**Shail Pandey**, Akash Agarwal and Deepak Joshi, "Rotating magnetic field configuration for controlled particle flux in material processing applications", International Journal of Materials Research 114, 746 - 750, 2023.
17.	Neha Sharma, Sadhana Matth, Raghavendra Pal, **Himanshu Pandey**, First-principles calculations of LaX3 (X: Sb, Sn) as electrode material for lithium-ion batteries., Energy Storage (Wiley), 6, e657, 2024.
18.	G. Venkat Swamy, P. K. Rout, **Himanshu Pandey**, B. Riscob, and G. A. Basheed, Magnetic domain structure and magneto-transport properties of laser ablated Co40Fe40B20 thin films. Nano Express (IOP) 4, 045002, 2023.
19.	Manoj Kumar, Sunil Chauhan, and **Himanshu Pandey**, Effect of Gd3+ Substitution on Structural, Morphological, and Magnetic Properties of BiFeO3 Nanoparticles. Journal of Sol-Gel Science and Technology (Springer) 109, 272, 2024.
20.	P Sharma, **DV Shah**, S Thakor, AD Watpade, VA Rana, CR Vaja, Compositional influence of synthesized magnetic nanoparticles on epoxy composites: dielectric, magnetic, and optical characteristics, Journal of Macromolecular Science, Part B 63 (5), 279-313, 2024
21.	A Pathak, YN Doshi, **DV Shah**, HN Desai, PB Patel, Synthesis and characterization of peculiar (Sb0. 2Sn0. 8) 0.5 (Se0. 9S0. 1) 0.5 crystal and its application as visible light photo-detector, Journal of Crystal Growth 618, 127308, 2023
22.	AD Watpade, S Thakor, P Jain, PP Mohapatra, CR Vaja, A Joshi, **DV Shah**,Comparative analysis of machine learning models for predicting dielectric properties in MoS2 nanofiller-reinforced epoxy composites, Ain Shams Engineering Journal 15 (6), 102754, 2024
23.	Y Doshi, A Raval, A Pathak, **DV Shah**, V Jain, J Tailor, H Desai, P Patel, Quaternary in0. 15sn0. 85 (se0. 95s0. 05) 2 crystal: synthesis, characterization, and its multiple applications, Materials Science in Semiconductor Processing 173, 108110, 2024
24.	AD Watpade, S Thakor, P Sharma, **DV Shah**, CR Vaja, P Jain, Synthesis, characterization, and dielectric spectroscopy of TiO2 and ZnO nanoparticle-reinforced epoxy composites, Journal of Materials Science: Materials in Electronics 35 (7), 466, 2024
25.	Y Doshi, V Jain, A Raval, A Pathak, S Yadav, **DV Shah**, H Desai, P Patel, A comprehensive analysis of In0. 15Sn0. 85 (Se0. 95S0. 05) 2 crystals as a promising material for self-powered photodetector, Optical Materials 144, 114295, 2023
26.	TR Jariwala, PP Desai, CK Tandel, NN Prajapati, YN Doshi, AV Raval, **DV Shah**, Comprehensive investigation of (Ge0. 03In0. 97)(Se0. 95S0. 05) crystals for multi-functional sensing and photo-catalytic applications, Optical Materials 149, 115071, 2024
27.	A Pathak, YN Doshi, **DV Shah**, HN Desai, PB Patel, S Sahoo, Optimizing the performance of (Sb0. 2Sn0. 8) 0.5 (S0. 9Se0. 1) 0.5 crystal-based self-powered photodetectors, Journal of Crystal Growth 627, 127494, 2024
28.	P Sharma, S Thakor, SJ Yadav, IA Shaikh, **DV Shah**, VA Rana, M Solanki, Hybrid nanofillers loaded epoxy resin; Synthesis, characterizations, and dielectric spectroscopy, Journal of Crystal Growth 628, 127551, 2024

29.	V Jain, Y Doshi, M Shah, J Ray, A Kedia, K Patel, **D Shah**, Enhancing dye degradation property of MoO3 nanoplates by vanadium doping, ECS Advances 2 (4), 042003, 2023
30.	S Sahoo, V Jain, **DV Shah**, R Das, A Pathak, Effect of Mo doping in vanadium pentoxide (V2O5) for dye degradation, Journal of Crystal Growth 627, 127491, 2024
31.	YN Doshi, AP Pathak, MS Shah, **DV Shah**, KK Patel, VM Jain, HN Desai, An exhaustive exploration of Zn0. 15Sn0. 85 (Se0. 95S0. 05) 2 crystal-based photodetector and its potential application as a photocatalytic material, Materials Research Bulletin 178, 112887, 2024
32.	A Pathak, YN Doshi, **DV Shah**, HN Desai, PB Patel, S Sahoo, AV Raval, Advancing photodetection capabilities via Pb-induced modifications in SnSe crystals, Journal of Materials Science: Materials in Electronics 35 (18), 1197, 2024
33.	P Sharma, SJ Yadav, **DV Shah**, Synthesis, Characterizations, and Applications of Fe3O4 and Co-Doped Fe3O4 Nanomaterials, Brazilian Journal of Physics 54 (3), 88, 2024
34.	CK Tandel, PP Desai, TR Jariwala, NN Prajapati, YN Doshi, AV Raval, **DV Shah**, Synthesis and characterization of PVA capped SnSe for IR sensor and piezo-resistive sensor applications, Journal of Materials Science: Materials in Electronics 35 (12), 849, 2024
35.	H Rajput, A Kedia, **D Shah**, Implication of Iron Oxide Nanoparticles Synthesized using Fruit Peel Extract as Antioxidant Agent and Catalytic Degradation, ECS Journal of Solid State Science and Technology 12 (11), 114001, 2023
36.	H Chauhan, A Jariwala, **Vipul Kheraj**. Luminescence-enhanced Diagnosis and Quantitative Assessment of Malarias Infection through Lateral Flow Immunoassay using CdTe Quantum Dots, Biophysics 68 (3) 495-501, 2023
37.	SS Parui, A Jariwala, **Vipul Kheraj**, Advancing stability and efficiency in perovskite solar cells: A novel approach using mixed cations based absorber layer, Materials Letters 363, 136244, 2024
38.	Porphyrin and its Co-doped Complex based Sensor Devices for Nitrogen and Sulphur Containing Environmental Toxic Gases, J. Gajjar and **D. R. Roy**, IEEE Sensor journal (IEEE Xplore) 24, 9411 - 9418, 2024.
39.	Group-III Phosphides and Arsenides Clusters as Potential Candidates for Single Molecular Device under DFT and NEGF Investigations, J. Gajjar, S. Trivedi and **D. R. Roy**, ACS Applied Electronic Materials (Amer. Chem. Soc.), 2024 in press.
40.	2D bilayer chromium pnictogens as a metallic material: DFT investigation of structural, vibrational, electronic, and elastic properties, P. Kumar, J. V. Gajjar, B. R. Mehta and **D. R. Roy**, Solid State Communications (Elsevier Sci.), 2024 in press.
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A. Conference / Workshops / Seminar / Symposium / Short Term Programmes organized

Sr. No.	Faculty	Name of Programme	Sponsoring Agency/ Self Financed	Period
1.	Dr. D. R. Roy, Dr. Yogesh Sonvane, Dr. D. V. Shah	Hands-on Session on Nanoscale Materials Devices Modelling and Simulations (NMDMS-2023)	Self Financed	11th Sep. -15th Sep. 2023
2.	Dr. Dipikia Patel, Prof. A. K. Rai, Dr. Vikash Kumar Ojha	BRNS-IANCAS National Workshop on "Radiochemistry and Applications of Radioisotopes"	BRNS & SERB	8th Jan. -12th Jan. 2024
3.	Dr. Vipul Kheraj	GIAN Course on "Advances in Physics and Technology of Laser Assisted Machining and Materials Processing"	GIAN, MoE, GoI	8th Jan. -12th Jan. 2024
4.	Dr. D. R. Roy, Dr. Atul R. Saraf, Dr. Deepak Joshi, Dr. S. N. Sharma	National Workshop on Research, Innovation & Entrepreneurship in Technical Education: NEP 2020	GTU, NIPER-A	10th Jan. -11th Feb. 2024

B. Ph.D. thesis reviewed as examiner outside SVNIT

Sr. No.	Faculty	Name of the University/Institute	Remark
1.	Dr. Debesh R. Roy	School of Science, RMIT University, Melbourne, Australia	February, 2024
2.	Dr. Debesh R. Roy	CHARUSAT University, Changa, India	December, 2023
3.	Dr. Yogesh Sonvane	Saurashtra University, Rajkot	2024

1. Sreejita Das

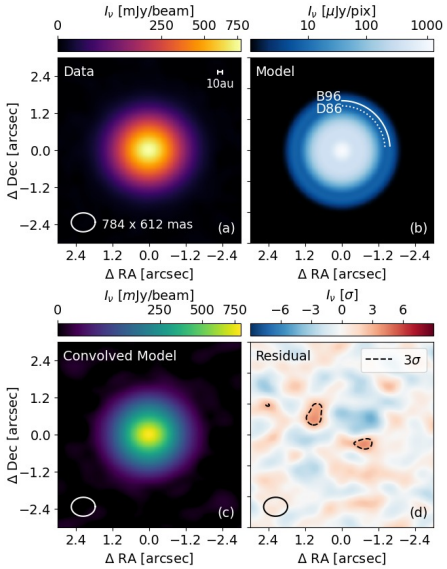
M.Sc. V, 2023-24

This year, I have been awarded the prestigious DAAD Research Grant- Doctoral Programmes in Germany 2024/25. I will pursue a PhD in Astrophysics at the Ludwig Maximilian University of Munich, with my research activities conducted at the European Southern Observatory (ESO) in Garching near Munich. Additionally, I will be registered with the International Max Planck Research School (IMPRS) on Astrophysics, as ESO is a member institution.

Applying for the DAAD grant involved several key steps. The most critical prerequisite was obtaining an invitation letter from the professor with whom I wished to work. Universities often have their own criteria, and in LMU's case, this included a minimum CGPA of 9.0 (1.5 in German grading). It's essential to have recommendation letter writers who are well-acquainted with your work and can speak highly of you. A well-thought-out research proposal and schedule are also crucial, as they demonstrate your preparedness and the feasibility of your planned research.

First, you submit all the required documents on the DAAD portal by the deadline. Around late January, you will be informed by email whether you have been shortlisted for the interview, known as the pre-selection stage. Expect questions that are both science-based and HR-related. In my case, I was asked general questions like, "What is the purpose of studying planet formation?" and specific topics from my proposal. Two unexpected questions were: "What is life?" and "What would you do if you discovered extra-terrestrial life?" The key is to remain calm and speak your mind. They are not looking for perfect answers but for the ability to think on the spot.

Although I cannot pinpoint what led to my selection, being a DAAD-WISE scholar, having a paper in preparation, and having a German scientist as a letter writer likely helped significantly. My PhD research is also a direct continuation of my Master's thesis, which strengthened my application. If you aim to pursue research in a new field, highlight how your current skills will support your future research endeavours. The Department of Physics has been instrumental in fostering a research-centric environment. I received invaluable support from my letter writers, particularly Dr. Debesh R. Roy, Dr. Ajay K. Rai, and Dr. Kamlesh N. Pathak. Their guidance, along with the support from all faculty members, helped me achieve strong academic performance, allowing me to focus on research opportunities. Moreover, dedicating an entire year to my thesis was crucial for the successful completion of my paper.



Here is a little bit about my research:
According to the NASA Exoplanet Archive, a total of 4,120 planetary systems have been confirmed. Yet, much remains unknown about their potential to support life or what makes our Solar System unique. Since a planet's habitability depends on its pre-birth environment, it is crucial to study the cradles where they formed- the protoplanetary disks. My research on TW Hya, the closest known disk, has identified significant structures in its outer region that had remained hidden despite a decade of observations. Utilising the revolutionary interferometer ALMA, I detected an outer ring at three new wavelengths, consisting of small dust grains totaling up to two Earth masses. During my PhD, I aim to delve deeper into these disks and their potential to answer the tantalising question of "how we came to be."

2. Darshil Domadiya

M.Sc. V, 2023-24

Hello friends,

I wanted to share some insights about the dissertation project I completed during the 2023-2024 academic year, as part of my final year in the MSc course at the Department of Physics, SVNIT. Our department uniquely initiated this year-long project to give students an opportunity for in-depth exploration and learning around a research problem. We were fortunate to visit and work in various labs across India and abroad. I strongly encourage you to consider applying for this opportunity.

In my pre-final year, I secured a summer internship under the SRFP 2023 by the Indian Academy of Sciences at Bhabha Atomic Research Centre (BARC), Mumbai. This was a funded two-month internship, and I thoroughly enjoyed the research environment at one of India's top government laboratories. The experience deepened my understanding of physics concepts and helped me decide on my research topic for the dissertation project. I applied for a one-year project under my internship guide and was selected to continue my research for the next year. My work focused on "Metal Oxide Semiconductor Heterostructures Thin Films for Toxic Gas Sensing Applications."

I am grateful to my guide, Dr. Betty C. A, as well as Dr. Sipra Chaoudhury and Mrs. Supriya Kanth, for their support during my project work at BARC Mumbai. I also extend my thanks to Dr. Vipul Kheraj, Dr. Dimple Shah, Dr. A. K. Rai, Dr. Debesh Roy, Dr. Yogesh Sonvane, and all the professors in the department for their assistance with documentation and permissions throughout the project. Special thanks to my seniors and batchmates for their camaraderie during the MSc journey.

If you're interested, you can apply to various research centres like BARC, ISRO, and other national labs. Make sure to carefully note the application procedures. Government-funded projects offer excellent facilities, so choose your project based on your interests and eligibility. For international research opportunities, you can apply for scholarships through portals like DAAD, CHARPAK, OIST, and MITACS for different countries. The common requirements usually include a Statement of Purpose (SOP), Resume, and Cover Letter, though specifics may vary by portal. Another option is to reach out to researchers directly via cold emails. For more details, feel free to contact seniors who have successfully navigated the process.

Kudos, Best of luck!

3. Bhavya Jaiman

M.Sc. V, 2023-24

I did my final year dissertation at the Solid State Physics Laboratory (SSPL) – DRDO in New Delhi where I worked with the Quantum Technology group. There are many labs under DRDO. You can apply for summer training to the Director of a suitable lab as per your discipline. You may visit the DRDO website https://drdo.gov.in for this purpose. Other guidelines are posted on the website. I applied online, but you can apply offline (by post) as well. Important documents included with the email are Resume, a Copy of University ID Card, a Training Letter from the Institute, and a scan of previous semester grade sheets. In the body of the email, include the start date and duration of training. You may add specific coursework/projects, and the reason for applying to the particular lab. Further instructions will be shared by email, once you are selected for the training.

During my fourth year, my electives were PH422 Global Navigation Satellite System, PH432 Microprocessors, PH425 Nanoscience and Nanotechnology, and, PH427 Material Science. This not only helped with the application but also during my work at the lab. At the start of Semester 8, I started looking for opportunities that were specific to my interest, as we had a course on Dissertation Preliminaries. Given my recent exposure and mini-project at the time, I chose SSPL and proceeded to apply there. I was provided with an offer letter, before my dissertation preliminary presentation.

The provision of opting for a full-year dissertation was an incredible opportunity. Dr Kamlesh Pathak sir helped me immensely with the formalities. My internal supervisor was Dr Vipul Kheraj, sir. He was also my examiner along with Dr Himanshu Pandey and Dr L. K. Saini. Dr Dimple Shah mam was my final mini-project supervisor. Dr Yogesh Sonavane sir was our course coordinator for dissertation preliminaries. Dr D. R. Roy sir was the head of the department at the time of my final submission of my dissertation. All the faculties were really supportive and encouraging. I am grateful to the Department of Physics, especially for providing early notice of presentation dates for our convenience.

DRDO is a place where the nation's best minds are at work. It is a place where one can hone their problem-solving skills to the fullest. Having done a literature review beforehand and reading extensively on the subject matter, proved incredibly helpful in catching me up to speed with my group. The scientists in our group were incredibly talented. My work at the lab was interdisciplinary and there was always something new to learn on the daily. While training at DRDO, I met distinguished people and brilliant scientists, which inspired me to work harder every day. I am honoured to have worked with them, in an organisation that serves to push the boundaries of science and technology, for our defence forces.

4. Vinit Pandya

M.Sc. V, 2023-24

DAAD India

MAX PLANCK INSTITUTE FOR PLASMA PHYSICS

In the fall of 2023, I found myself eagerly drafting an email that would shape the course of my academic career. The recipient was Dr. Hans Meister, the head of ITER Diagnostic at the Max Planck Institute for Plasma Physics in Garching, Germany. I was interested in the field of Bolometer Tomography, and I knew that if there was one place to deepen my understanding, MP-IPP was the best institute for that.

With a personalised mail, I attached my CV and outlined my enthusiasm for the subject. To my delight, Dr. Hans took my request seriously and, after discussing it with his superiors, decided to give me a chance. This opportunity led me to apply for the DAAD-WISE Scholarship, a prestigious program that supports Indian students undertaking research internships in Germany. I poured all my academic achievements into the application, knowing that this was a once-in-a-lifetime opportunity. In February, I received the news I had been hoping for—I was awarded the scholarship. The DAAD-WISE fellowship provided me with €934 per month, along with an additional €1425 for travel expenses, making my research aspirations a reality.

The internship

My three months at the Max Planck Institute were nothing short of transformative. I worked closely with a team of brilliant scientists, focusing primarily on the optimization of collimator geometry for the ITER bolometers, a critical component in plasma diagnostics. My role involved updating the geometries within the ITER Integrated Modeling & Analysis Suite (IMAS) environment, ensuring that the bolometers would function with maximum efficiency in the ITER project. The experience of working on such a significant project, surrounded by experts in the field, was both humbling and exhilarating. Every day presented new challenges and learning opportunities, and I was grateful for the chance to contribute to a project that has the potential to shape the future of energy.

A Message to Aspiring Researchers

For those of you considering a similar path, I encourage you to pursue it with all your heart. Opportunities like the DAAD-WISE fellowship don't just land in your lap; they require preparation, persistence, and passion. Start by identifying your area of interest and reach out to professionals in the field. A well-written email, backed by a solid academic record, can open doors you never imagined.

Remember, securing a fellowship or internship is just the beginning. The real growth happens when you're in the thick of research, navigating the complexities of your project, and learning from those around you. Take initiative, ask questions, and immerse yourself in the experience. These internships are more than just a line on your CV—they're a chance to contribute to something greater, to learn deeply, and to build connections that will support your career for years to come.

5. Sidharth Ramesh

M.Sc. V, 2023-24

DAAD India

Leibniz Association

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

I have completed my Integrated M.Sc degree and currently got a PhD position at TU/e (Eindhoven University Of Technology).

I usually stay updated on recent papers related to my topic of interest, which is cold atmospheric plasma. As I read these papers, I pay attention to the authors, particularly those who are actively contributing to this field. This approach also helps me identify various research groups that are focused on these topics. By doing so, I compile a list of professors who I can potentially reach out to for internship opportunities or to further explore the subject.

I typically send cold emails to these professors, using the contact information provided on their websites or in the research papers. In these emails, I express my interest in their work and inquire about any available opportunities. If they respond, we can discuss the possibilities, including funding options.

Some professors might offer funding directly, while others might guide me towards funding options available through their universities. For instance, certain universities have internal systems that provide funding for internships, but you often need a professor from that university to support your application. Additionally, there are external programs like DAAD-WISE, Charpak, and others that can help secure funding once you have a professor willing to supervise your internship. This is how I typically approach the process of securing an internship.

When I applied for the DAAD-WISE program during the summer, I had to first find a professor in Germany, so I began by sending cold emails to various professors across the country. After contacting many, I was fortunate to receive a positive response from a professor at the Leibniz Institute for Plasma Science and Technology (INP) in Greifswald, Germany. Once the professor agreed to take me on, he provided me with project proposals and assisted with my statement of purpose and other required documents, which are listed on the DAAD website.

The application process involved submitting several documents, including project proposals, completed forms (easily available online), and a statement of purpose. In the statement of purpose, I had to detail my research journey, starting from my early interest in physics during school, through to my focus on nuclear physics, and eventually onto plasma physics and cold atmospheric plasma, guided by various internships and experiences.

Additionally, two letters of recommendation from professors were required. Once all the documents were submitted, the application was reviewed, and I received confirmation of selection by January or February. After acceptance, DAAD assigns specific personnel to assist with the visa process and other necessary documentation.

The most challenging part of the process, in my opinion, is securing a professor who is willing to offer you an internship. Once that hurdle is cleared, the rest of the process involves clear communication and following the required steps.

The selection process for my internship with the professor in Germany was relatively casual, though it can vary depending on the individual. In my case, I reached out to the professor after following his work and emailed him expressing my interest. After reviewing my CV, he was interested in my background and suggested a face-to-face Zoom call. During the call, we discussed my knowledge and experience, and he appreciated my honesty when I admitted to areas where I lacked expertise. This honesty allowed us to have a clear understanding of what I would need to learn, ensuring that the work ahead would be manageable and free of unrealistic expectations.

After this initial conversation, the professor expressed his satisfaction with my profile. We then had a few additional meetings to discuss funding and other details. He also asked me to write a project proposal on my own, which helped him gauge my understanding of the research topic. Once that was completed, he was pleased with my proposal and decided to offer me the internship.

A common trend I've noticed among students is that their first priority is often to secure internships outside the university, without fully utilising the resources available on campus. I was initially under the same misconception, not making the most of what my university had to offer. However, during my third year, when I couldn't secure an external internship, I decided to work with Dr. Shail Pandey in the Physics department. This experience during my summer internship turned out to be incredibly valuable. I was able to dedicate significant time to the work, which allowed me to learn a lot of new concepts, conduct a thorough literature survey, and deepen my understanding of the subject.

In addition to this, the mini project component of our curriculum played a crucial role in my development. These mini projects required us to work on specific research topics for four to six months during the semester. My first mini project focused on the effects of cold atmospheric plasma on cancer, and in the following semester, I expanded this research to explore its applications for SARS-CoV-2 and other areas. This hands-on experience helped me build a solid foundation in my research area by allowing me to explore different aspects of cold atmospheric plasma.

Working closely with my professor, I gained practical experience with simulation software and learned key tools essential for my research. The combination of working independently on mini projects and doing an internship within my university, especially during the summer of my third year, significantly boosted my confidence and expertise in the field. This experience was instrumental in helping me secure my subsequent internship.

At SVNIT, Dr. Shail Pandey was my mentor, and she played a crucial role in my development. She helped me learn and use software like COMSOL and provided me the opportunity to work alongside her PhD students, which allowed me to gain valuable insights into conducting research properly. Under her guidance, I was able to dive deep into the field of Cold Atmospheric Plasma. She was always open and welcoming to my suggestions, creating a friendly and supportive environment that encouraged me to make mistakes, learn from them, and grow.

During my time at the German university, I was mentored by Dr. Torsten Gerling and Dr. Philipp Mattern, who guided me through my dissertation. They taught me critical skills such as how to create precise presentations, communicate doubts effectively, schedule meetings, maintain proper laboratory discipline, and more. These skills are vital when working abroad and in a major laboratory setting. The experience of planning and scheduling my year-long dissertation work was invaluable, teaching me how to manage projects, assess risks, and track progress.

Both my mentors in Germany and Dr. Pandey at SVNIT provided me with excellent letters of recommendation, which played a significant role in helping me secure a PhD position. The letters were honest, highlighting both my strengths and weaknesses, which gave the hiring committee a clear understanding of my character and capabilities. I feel incredibly fortunate to have had such supportive mentors, and I hope to continue building on the foundations they helped me establish.

"The Allure of Magnetic Monopoles"

Pranav Iyer
(M.Sc. IV, 2023-24)

A simple glance at Gauss's Law of Magnetism leads us to the conclusion that magnetic monopoles cannot exist-

$$\oint \mathbf{B} \cdot d\mathbf{S} = 0$$

Magnetic flux through a closed surface is zero; field lines cannot converge to or diverge from it. The question we seek to answer here is how magnetic monopoles could possibly exist, and why their existence matters to the larger picture of physics despite a clear lack of empirical evidence thus far. To try and get somewhere from this seemingly dead end, we want to modify Gauss law to allow the existence of a magnetic charge g. We can also rewrite the expression in terms of the magnetic potential and use Stokes' Theorem to simplify it:

$$\oint \mathbf{B} \cdot d\mathbf{S} = g$$

$$\oint (\nabla \times \mathbf{A}) \cdot d\mathbf{S} = g = \oint \mathbf{A} \cdot d\mathbf{S}$$

Now we have the statement in terms of a substantially less stringent quantity, the magnetic vector potential. Something very unique about field theories in physics is that the magnetic and electric potentials are not measurable quantities and they are equivalent up to a very specific kind of transformation. The gauge symmetry of these fields dictate the kind of transformation that we can do while still leaving the field strength quantities, which are measurable, invariant. In the case of classical electromagnetism, the gauge transformations of the magnetic and electric potential are as such:

$$\mathbf{A} \mapsto \mathbf{A} + \nabla\chi$$

$$V \mapsto V - \frac{\partial\chi}{\partial t}$$

However, we would like to work in the framework of quantum mechanics, where we must describe the Gauge transformation in terms of the phase transformation of the wavefunction:

$$\psi \mapsto e^{-ie\chi}\psi$$

$$\vec{A} \mapsto \vec{A} - \vec{\nabla}\chi \equiv \vec{A} - \frac{i}{e}e^{ie\chi}\vec{\nabla}e^{-ie\chi}$$

It turns out, due to this redundancy brought about by gauge symmetry, we can actually use different expressions for the vector potential as long as we ensure that their difference on regions where they overlap correspond to a gauge transformation. To do this, let us take a spherical surface around our monopole. We know intuitively that the magnetic field strength of a monopole should look like this (setting fundamental constants equal to 1):

$$\vec{B} = \frac{g}{4\pi r^2}\hat{r}$$

Now we divide the region into two halves, North N with the of θ running from 0 to π/2, and South S with θ running from π/2 to π with the two fields overlapping at θ = π/2 which is the equator. The vector potential on the two halves can be taken as:

$$\vec{A}_N = \frac{g}{4\pi r}\frac{(1-\cos\theta)}{\sin\theta}\hat{e}_\phi$$
$$\vec{A}_S = -\frac{g}{4\pi r}\frac{(1+\cos\theta)}{\sin\theta}\hat{e}_\phi.$$

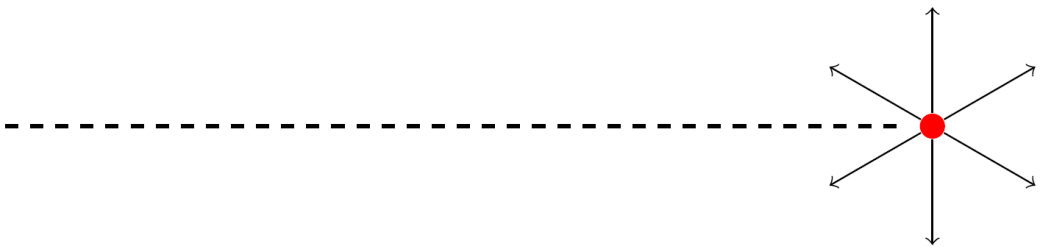
You can see for yourself that both these expressions result in the same **B** we started with. As we can see, Gauss' Law now gives us the enclosed magnetic charge within this sphere:

$$g = \int_N \vec{B}_N \cdot d\vec{S} + \int_S \vec{B}_S \cdot d\vec{S} = \int_E \left(\vec{A}_N - \vec{A}_S\right) \cdot d\vec{l} = \chi(0) - \chi(2\pi).$$

Note that the gauge function χ is seemingly discontinuous here, as ϕ is periodic at interval 2π. Surprisingly, this isn't a problem since we are working in a quantum framework where the physical observables are actually dependent on e^(−ieχ) which can be made to be continuous by the condition e^(−ieχ(0)) = e^(−ieχ(2π)). This implies that:

$$e^{-ieg} = 1$$
$$\implies eg = 2\pi n, \quad n \in Z$$

This is why we continue looking for the existence of magnetic monopoles in particle accelerators and in cosmological events; they explain why electric charge is quantized in nature! The existence of a single magnetic charge forces every electric charge to be quantized (and vice versa). Another interesting result from this procedure is the existence of a topological defect, a string resultant from the discontinuity of the gauge function from the monopole to infinity.



This is called the **Dirac String** (indicated by the dashed lines) and due to the condition we enforced to result in quantization of charge, this string is an unobservable construct. Since Dirac's work on this, consequent procedures have been devised that do not result in any topological defects in space, but there is appreciable beauty in a one dimensional mathematical singularity that extends through all of space.

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"The Beauty of Helicity"

Sneh Shah
(M.Sc. IV, 2023-24)

The aim of this article is to explain the beauty of helicity conservation in fluids (in hydrodynamic as well as the magnetohydrodynamic case) in a simple manner while keeping intact its mathematical rigorosity. The reader is assumed to have the fundamental knowledge of fluid dynamics, electrodynamics and topology. Understanding of basic MHD (magnetohydrodynamics) can be helpful, but is not necessary. The author advises the reader to go through the references for more details.

Fluid dynamics has been a tough nut to crack throughout centuries, as evident from the unsolvability of the Navier-Stokes (N-S) equations (in 3 spatial dimensions). It has been an unsolved problem for over 200 years [1], which is yet to be understood completely. Conservation laws help a lot in understanding flow complexities and put restrains, in some way, regarding how things can not be. Fluid dynamicists are always looking for such quantities as help us understand the fundamentals of fluid flow. One such quantity, called Helicity (H), was discovered and studied in 1958 for MHD systems by Woltjer [2] and for hydrodynamics in 1961 by Moreau [3]. However, it is interesting to note that they are essentially the same mathematically and can be generalized for any arbitrary divergenceless vector.

The Euler equations [4] (divergenceless, dissipation-free version of N-S) are given as

$$\nabla \cdot \mathbf{u} = 0 \tag{1}$$

$$\frac{\partial \mathbf{u}}{\partial t} + (\mathbf{u} \cdot \nabla)\mathbf{u} = -\nabla P + \nabla \phi \tag{2}$$

where **u** is equivalent to **u**(**x**, t) is the flow velocity, P is the pressure and ϕ is any scalar potential. We then write the vorticity as

$$\mathbf{w}(\mathbf{x}, t) = \nabla \times \mathbf{u} \tag{3}$$

Taking the curl of second N-S equation gives the vorticity equation

$$\frac{\partial \mathbf{w}}{\partial t} = \nabla \times (\mathbf{u} \times \mathbf{w}) \tag{4}$$

The kinetic helicity is then defined as

$$\mathcal{H} = \int_V (\mathbf{u} \cdot \mathbf{w})\ d^3\mathbf{x} \equiv \int_V (\mathbf{u} \cdot (\nabla \times \mathbf{u}))\ d^3\mathbf{x} \tag{5}$$

It can then be proved using appropriate boundary conditions that helicity is conserved under an Eulerian flow (the proof is skipped and left as an exercise for the reader)

$$\frac{d\mathcal{H}}{dt} = 0 \tag{6}$$

With respect to ideal MHD (no dissipation), Maxwell's equations can be used to write what is known as the induction equation (perhaps the most important equation in all of MHD) (for derivation, see [5])

$$\frac{\partial \mathbf{B}}{\partial t} = \nabla \times (\mathbf{u} \times \mathbf{B}) \tag{7}$$

Since **B** is a divergenceless quantity, we can write it in the form of a magnetic vector potential

$$\mathbf{B} = \nabla \times \mathbf{A} \tag{8}$$

such that $\nabla \cdot A = 0$. (Gauge freedom)

We can now start seeing the parallels between the hydrodynamic and the magnetohydrodynamic case. The magnetic helicity is then defined as

$$\mathcal{H}_m = \int_V (\mathbf{A} \cdot \mathbf{B})\ d^3\mathbf{x} \equiv \int_V (\mathbf{A} \cdot (\nabla \times \mathbf{A}))\ d^3\mathbf{x} \tag{9}$$

Again, a simple mathematical exercise can be done to prove that magnetic helicity is a conserved quantity ($d\mathcal{H}_m/dt = 0$).

Now, let us understand the parallels between both cases. In the hydrodynamic case, **w** is given as the curl of another vector **u** with $\nabla \cdot \mathbf{u} = 0$. In the MHD case, **B** is given as the curl of another vector **A** with $\nabla \cdot \mathbf{A} = 0$. Also, for both **w** and **B**, their time-evolving equations are of the sa me form (see equations (4) and (7)). To understand what helicity is physically and why is it a conserved quantity, we need to dive a bit into topology (specifically knot theory).

Helicity is the measure of linkage, twist [6] and writhe [7] of magnetic fields, and turns out that it is proportional to the linking number (which is the sum of twist and writhe)

$$Lk = Tw + Wr \tag{10}$$

It is a well-known result in topology that this quantity is a numerical invariant under continuous deformations [8] [9]. To understand this invariance in detail, the reader can refer [9] and [10]. And, since helicity is proportional to the linking number, it is also a conserved quantity in time. To understand the topological beauty of helicity further, refer to [11] and [12].

Author's note: In light of equations (5) and (9), some readers might come across a doubt – for any arbitrary vector $\mathbf{P} \cdot \nabla \times \mathbf{P}$ is perpendicular to **P**. So, should not $\mathbf{P} \cdot (\nabla \times \mathbf{P})$ equal 0? Well, no. The statement that a curl of a vector is perpendicular to the vector is not necessarily true. The cross product of two vectors and the curl of a vector are mathematically different things and should not be confused. Hence, $\mathbf{P} \cdot (\nabla \times \mathbf{P})$ in general shall be non-zero.

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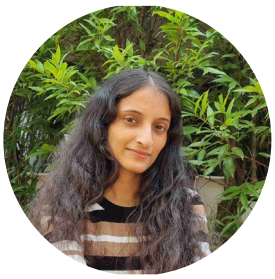

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