Annual Report
&
Audited Statement of Accounts
2021-22

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Institute of Physics
Bhubaneswar

Annual Report

and

Audited Statement of Accounts

2021-22

Institute of Physics

Bhubaneswar

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About the Institute

Institute of Physics, Bhubaneswar is an autonomous research institution within the Department of Atomic Energy (DAE), Government of India. The Institute was established in 1972 by the Government of Odisha and continues to receive financial assistance from DAE and Govt. of Odisha.

The Institute has a vibrant research programme in the fields of theoretical and experimental condensed matter physics, theoretical high energy physics and string theory, theoretical nuclear physics, ultra-relativistic heavy-ion collisions and cosmology, quantum information and experimental high energy nuclear physics. The accelerator facilities include a 3MV Pelletron accelerator and a low-energy implanter. These are being used for studies in low energy nuclear physics, ion beam interactions, surface modification and analysis, trace elemental analysis, materials characterization, and radiocarbon dating studies. One of the important areas in the Institute is in the field of Nanoscience and Nanotechnology in general and surface and interface studies in particular. The Institute has several advanced facilities for sample preparation and for the study of various physical and chemical properties of nanostructures and bulk condensed matter systems. The Institute is actively involved in the International Collaborations with CERN (Switzerland), BNL (USA), ANL (USA), GSI (Germany), and other laboratories abroad. The Institute is also participating in various research activities related to India-based Neutrino observatory.

The Institute offers Ph.D. programme in Physics. Selected students are required to successfully complete one-year course work at the Institute. The selection for the doctoral programme is through the Joint Entrance Screening Test (JEST). Candidates who have high CSIR-UGC NET or GATE scores are also eligible for admission to the doctoral program.

The Institute campus has housing facilities for the employees and hostels for the scholars and post-doctoral fellows. Compact efficiency apartments are available for post-doctoral fellows and visitors. Both indoor and outdoor games and sports facilities are also available in the campus. The Institute has a mini-gym in the New Hostel. The Institute also has a guest house, auditorium, and dispensary in the campus. The Foundation Day of the Institute is celebrated on 4th of September every year.

CHAIRMAN AND MEMBERS OF THE GOVERNING COUNCIL FOR THE YEAR 2021-22

1.	Dr. K. N. Vyas, Chairman, Atomic Energy Commission and Secretary to Govt. of India, Department of Atomic Energy Anushakti Bhavan, C.S.M.Marg, Mumbai	:	Chairman
2.	Prof. S. M. Yusuf, Director, Institute of Physics Bhubaneswar - 751 005 (From 23.01.2020 to 15.06.2021)	:	Member
3.	Prof. K. K. Nanda, Director, Institute of Physics Bhubaneswar - 751005 (Since 16.06.2021)	:	Member
4.	Prof. Pinaki Majumdar, Director, Harish-Chandra Research Institute Chhatnag Road, Jhunsi, Allahabad-211019	:	Member
5.	Prof. Gautam Bhattacharyya, Director Saha Institute of Nuclear Physics Sector-1, Block-A/F, Bidhan Nagar, Kolkata-700064	:	Member
6.	Prof. Sudhakar Panda, Director National Institute of Science Education and Research Post. Bhimpur-Padanpur, Via. Jatni, Khurda - 752050	:	Member
7.	Dr. Shashank Chaturvedi, Director, Institute for Plasma Research Bhat Village, Near Indira Bridge, Gandhinagar-382428	:	Member
8.	Smt. Sushma Taishete, Joint Secretary (R&D), Department of Atomic Energy Anushakti Bhavan, C.S.M.Marg, Mumbai-400001	:	Member
9.	Smt. Richa Bagla, IAS, Joint Secretary (Finance) Department of Atomic Energy Anushakti Bhavan C. S. M. Marg, Mumbai-400 001	:	Member
10.	Shri Deoranjan Singh, IAS Principal Secretary, Science and Technology Department. Odisha Secretariat Bhubaneswar-751001. (*From 09.08.2020 to 31.03.2021*)	:	Member
11.	Shri Manoj Kumar Mishra, IRTS, Science and Technology Department, Secretary to Govt. of Odisha Odisha Secretariat, Bhubaneswar-751001 (*Since 01.04.2021*)	:	Member
12.	Prof. Surya Narayan Nayak, Department of Physics, Sambalpur University, Jyoti Vihar, Burla, Sambalpur-768019	:	Member
13.	Prof. Sukanta Kumar Tripathy, P. G. Department of Physics, Berhampur University, Bhanja Bihar, Ganjam-760007.	:	Member

Secretary to the Governing Council

Shri R. K. Rath, Registrar, *(upto 31.07.2022)*, **Prof. P. K. Sahu**, *(from 01.08.2022)*
Institute of Physics, Bhubaneswar - 751005

From the Director's Desk

It is my pleasure to present before you the "Annual Report and Audited Statement of Accounts" of Institute of Physics (IOP), Bhubaneswar for the financial year 2021-22. A summary of our academic and research endeavours as well as our accomplishments can be found in this year's Annual Report. IOP, Bhubaneswar is an autonomous research Institute funded by the Department of Atomic Energy (DAE), Government of India. It is one of the leading research institutes in India and its mission is to conduct high-quality research at the cutting edge of both experimental and theoretical physics. More specifically, the Institute focuses on theoretical and experimental high energy physics, condensed matter physics and theoretical nuclear physics.

This year, IOP members have published 101 research papers in high-quality international peer-reviewed journals, demonstrating the exceptional level of research being conducted by these individuals. Further, IoP members have published 118 research papers collectively through ALICE & CMS Collaboration. Apart from 229 research papers, members of IoP have also written 11 book chapters included high-quality conference proceedings.

Members of the Institute have received many accolades. Prof. S. K. Agarwalla, one of the HEP group members has received the prestigious Fulbright-Nehru Academic & Professional Excellence Fellowship (FNAPE) and is appointed as Honorary Fellow of the Physics Department, University of Wisconsin-Madison, Madison, USA. He is also Associate Membership of the Abdus Salam International Centre for Theoretical Physics (ICTP) and featured in the Coffee Table Book titled "75 Scientists under 50"as a part of the Golden Jubilee Celebrations of the Department of Science and Technology (DST), Governement of India for the year 2021 – 2022. Prof. Shikha Varma has been elected as Endowment Chair Professor, Dr. K. C. Patel Research & Development Center (KRADLE). Prof. T. Som continues as Executive Body Member (Eastern India), Ion Beam Society of India. Prof. Shamik Banerjee was awarded the prestigious DST Swarnajayanti Fellowship for the year 2021 in the Physical Science and Dr Manimala Mitra received IPPP Diva Award 2022. Our scholars Ms. Rojalin Padhan has received a prestigious Fulbright-Nehru Doctoral Research Fellowship and Mr. Vinaykrishnan is a group Convener as Level-3 Tau-Trigger, CMS collaboration.

The Institute conducted outreach programs for communicating Science and scientific inspiration to school and college students, teachers and public. Our members enthusiastically celebrated National Science Day by organizing "Open Day". The Institute also observed the 47th Foundation Day on 4th September 2021 in which eminent Professors in Physics across

India (*namely, Prof. Tarun Souradeep, Chair, Department of Physics, IISER, Pune; Prof. Amit Roy, Ex-Director, IUAC; Prof. Pinaki Majumdar, Director, HRI; & Prof. Gautam Bhattacharyya, Director, SINP, Kolkatta*) delivered Foundation Day Lectures on different domains of Physics.

Institute is also engaged in other activities like night sky watch with the telescopes, Popular Science talks as well as talks on social issues. Notebly, an outreach programme on "Atomic Energy Application to Society" was conducted for rural areas. Also IoP, Bhubaneswar celebrated "Azadi Ka Amrit Mahotsav" on the eve of the 75th year of Independence by carrying out activities such as Kalinga TV programme on Samanta Chandrasekhara, Bigyan Sarbatra Pujyate, Hindi Workshop, and a series of Physics Open Discussions (PODs) in association with various schools and colleges.

At last, I would like to take this opportunity to offer my most sincere gratitude to the members of the IoP community, including the Governing Council members for their continuous support and advices. In addition, I would like to thank all the faculty and staff and recognise the efforts that the committee members have put in this Annual Report.

Professor Karuna Kar Nanda
Director, IOP

Contribution of Institute of Physics (IOP) towards DAE Vision

Brief Summary of Annual Report 2021-2022

Institute of Physics (IOP) is a major center for research in basic and applied physics. The research is carried out in the following broad areas of physics, namely, theoretical high energy physics, theoretical condensed matter physics, theoretical nuclear physics, experimental condensed matter physics, experimental high energy physics, and quantum information.

The high energy physics group of the institute is actively working in many areas – formal field theory, string theory, heavy-ion collisions, QCD, radiative corrections, neutrino physics, beyond the standard model scenarios and their phenomenology, and quantum information. In particular, the members have worked on Hawking radiation from acoustic black holes, scattering amplitudes and asymptotic symmetry in asymptotically flat four-dimensional space-time. In addition, the group members have investigated the phenomenology of radiative neutrino mass models, signatures and bounds on the parameters of the seesaw models, FIMP dark matter, sterile neutrinos, and muon anomalous magnetic moment puzzle related models, sub-leading BSM affects on the neutrino mass-mixing parameters at the future high-precision accelerator long-baseline neutrino oscillation experiments such as DUNE in USA and T2HK in Japan and atmospheric neutrino experiment at the upcoming India-based Neutrino Observatory (INO), determination of the Higgs boson couplings at hadron colliders, one-loop QCD corrections. Prof. Sanjib Agarwalla received the prestigious Fulbright-Nehru Academic and Professional Excellence Fellowship (FNAPE) for the year 2021 – 2022 and Associate Membership of the Abdus Salam International Centre for Theoretical Physics (ICTP) for Six Years (2022 to 2027). Prof Shamik Banerjee has been awarded the prestigious Swarnajayanti Fellowship (DST, Govt. of India) in Physics for the year 2021-2022.

The condensed matter theory group at IOP is actively involved in pursuing research with the main focus on understanding the organization of bacterial chromosome, various aspects of active matter, pattern formation, topological aspects of quantum condensed matter systems, driven higher-order topological systems, quantum transport in Dirac/Weyl materials, twisted bilayer systems, quantum magnetism, and strongly correlated electrons. The group members have investigated exact dynamical moments for trapped active Brownian particles to show a re-entrant non-equilibrium transition, emergence of dynamical pattern formation and running waves on spherical membranes due to active cytoskeletal proteins, time-reversal broken tight-

binding model describing Kane-Mele model superimposed with Haldane model where eight different quantum hall effect including quantum anomalous Hall phases appear with one topological spin sector and multiple critical point with two topological phase co-existence, Floquet generation of a second-order topological superconducting phase hosting Majorana corner modes, considering a quantum spin Hall insulator with a proximity induced superconducting s-wave and d-wave pairing in it, systematic generation of the cascade of anomalous dynamical first and higher-order modes in Floquet topological insulators, emergence of non-Hermitian physics at the heterojunction of a type-II Dirac semimetal and a dirty superconductor.

The experimental high energy physics groups at IOP are participating in the collider-based experiments at various international laboratories, such as CMS and ALICE experiments at CERN-LHC, STAR experiment at RHIC, BNL (USA), and the CBM experiment at FAIR, GSI (Germany). The CMS group at IOP contributed to the measurement of CP structure of the Yukawa coupling between the Higgs boson and tau leptons in proton-proton collisions at centre-of-mass energy of 13 TeV using the data recorded by the CMS experiment at LHC. Furthermore, its members are taking leadership roles in the development of CMS high-level trigger system for recording data during LHC Run-3, which will be starting in 2022.

The Theoretical Nuclear Physics (TNP) Group at the Institute of Physics is actively involved in various areas of front line research work. They studied the structure of neutron star along with their merger to estimate the Gravitational Wave Strain. The group studied the various modes of oscillation of neutron star, cooling of Neutron Star and Supernovae and the Dark Matter effects. The group also constructed various equations of state, which will be used by various astrophysics groups. In collaboration with other groups, the TNP group at IOP have also studied Nuclear Reaction Dynamics and various exotic structures of finite nuclei. The members are taking part in various developments of Nuclear and Astrophysics programs both Nationally and Internationally.

The experimental condensed matter group at IOP is actively involved in the cutting-edge research that focuses on Brain-inspired computing, Resistive switching, ion beam induced self-organized pattern formation and their nanoscale functionalization, photovoltaics, nano-bio glucose sensing and ion-beam modification of materials, organic and DNA overlayers for the understanding of interaction mechanism and sequestration of toxic materials like Mercury and Arsenic, novel electronic and magnetic phenomena in atomically engineered thin films/ heterostructures, thermoelectric, electronic band structures of advanced materials and understanding of physical properties of atomically thin two dimensional layered materials such as graphene, transition metal dichalcogenides etc. In addition, the group is working on the

development of a low-to-medium energy ion beam facility. The low energy 3 MV Pelletron accelerator of IoP is used by different external users to carry out their research. The work of Prof. Satyaprakash Sahoo's group on Electric Field Modulated Charge Transfer in Geometrically Tailored MoX_2/WX_2(X=S,Se) Heterostructures appeared as Cover page of The Journal of Physical Chemistry C (2021).

Among other activities, IOP has conducted many activities under the program "Azadi Ka Amrit Mahotsav (AKAM)" since September 2021 which includes; Tree plantation and cleanness drive on Gandhi Jayanti, Scientists and school students online interaction program, Training program on Official Language Policy, Functional Hindi & Computation and Translation. These are published on Govt. of India, AKAM website. As part of the celebration of National Science Day 2022, IOP has organized an "OPEN DAY" first of its kind by the initiative of Prof. K. K Nanda, Director, IOP to create more scientific awareness among the student community, teachers, parents, technology enthusiasts and the general public. It featured live demo experiments, laboratory and library visits, and scientific poster presentations. Many other activities such as, a one-day seminar on "energy, radiation and materials" at Centurion University, Jatni, a Night-Sky-view session at IOP, an awareness programme on "Societal applications of the atomic energy" in a rural village at Khurda and inauguration of Lecture Hall, Block-A have also been conducted. There are plans to organize many outreach programs based on DAE activities and IOP programs in different parts of Odisha state, particularly in rural village schools and colleges.

ACADEMIC PROGRAMMES

1.1 PRE-DOCTORAL PROGRAM

One of the most important objectives of the Institute is to train and guide young scholars to do research in physics. Since 1975, IOP has a regular Pre-doctoral (Post M.Sc.) course, which is a very important academic program because it is designed to train the M.Sc. students for carrying out research activities. This programme is aimed at imparting a broad based training in advanced physics and research methodology to students. The course work is planned with the view that it should help the students not only in doctoral research, but also enable him/her to become a good physics teacher. The Institute participates in conducting the Joint Entrance Screening Test (JEST) to select students who are interested in pursuing Ph.D. in physics. The final selection of a student is based on the result of written test and an interview conducted at the institute. This year the Pre-doctoral course began in January 2022. On completion of the Pre-doctoral program, students are eligible to join research under the supervision of faculty members of the Institute, leading to the Ph.D. degree awarded by Homi Bhabha National Institute (HBNI).

The Institute has instituted Lalit Kumar Panda Memorial Endowment Fellowship (*L. K. Panda Memorial Fellowship) to recognize the talent for the* most outstanding pre-doctoral student. The fellowship consists of an award of Rs.5,000/- and a citation. Last year the awardee was Mr Manish Patel.

A total of 51 students were called for written test and interview for admission to the pre doctoral course in December, 2021. This includes JEST qualifiers, UGC-CSIR qualifiers and valid GATE score holders. Following students enrolled to the doctoral course work program for the year 2021-2022:

1. Mr. Alok Kumar
2. Ms. Sayari Ghatak
3. Mr. Ashish Kumar Panigrahi
4. Mr. Rahul Puri
5. Mr. Sayak Bhowmik
6. Mr. Debabrata Dey
7. Mr. Nevin Noble
8. Ms. Subhalaxmi Rout
9. Mr. Nabendu Mondal
10. Mr. Subhransu Sekhar Mishra
11. Mr. Aditya Mehta

Details of the courses offered and course instructors are given below.

Semester – I

Advanced Quantum Mechanics	:	Dr. Kirtiman Ghosh
Advanced Statistical Mechanics	:	Prof. Debasish Chaudhuri
Quantum Field Theory – I	:	Prof. Shamik Banerjee
Advanced Experimental Techniques	:	Prof. T. Som
Experimental Physics Lab	:	Prof. T. Som
Many Body Physics	:	Prof. Arijit Saha

Semester – II

Numerical Methods Mathematical Methods

Mathematical Methods	:	Prof. Goutam Tripathy
Advanced Condensed Matter Physics	:	Prof. Arijit Saha
Quantum Field Theory – II	:	Prof. Pankaj Agrawal
High Energy Physics	:	Dr. Manimala Mitra
Special Topics in Statistical Physics	:	Prof. Debasish Chaudhuri
Special topics in Condensed Matter Physics	:	Prof. B. R. Sekhar, Dr. Debakanta Samal

As a part of the course work, students also worked on projects in the last Semester under supervision of faculty members of the institute.

1.2 DOCTORAL PROGRAM

Presently Institute has fifty Nine doctoral scholars working in different areas under the supervision of its faculty members. All the scholars are registered with Homi Bhabha National Institute (HBNI), a deemed-to-be University within DAE. Progress of each doctoral scholar is reviewed annually by a review committee. This year reviews were held in the months of July-August.

1.3 THESES (Submitted / *Defended)

The following scholars have been awarded Ph.D. degree by Homi Bhabha National Institute on the basis of thesis submitted / *defended.

1. **Mr. Sujay Shil**

Advisor: Prof. Pankaj Agrawal

Thesis Title: "Signatures of Seesaw Models at Colliders"

2. **Mr. Amir Shee**

Advisor: Prof. Debasish Chaudhuri

Thesis Title: "Studies on Active Systems"

3. **Mr. Sayan Jana**

Advisor: Prof. Arijit Saha

Thesis Title: "Zero-energy modes and strong correlation effects in topological systems"

4. **Mr. Debjyoti Majumdar**

Advisor: Prof. Goutam Tripathy

Thesis Title: "Rigidity and collapse of melting DNA"

5. **Mr. Atanu Maity**

Advisor: Prof. Saptarshi Mandal

Thesis Title: "Classical Orders, VBS, QSL in Fisher Lattice & Spin Wave Analysis in Hollandite Lattice"

6. **Mr. Vijigiri Vikas***

Advisor: Prof. Saptarshi Mandal

Thesis Title: "Some aspects of proton dynamics in squaric acid crystal using pseudo-spin formalism"

7. **Mr. Sujay Shil***

Advisor: Prof. Pankaj Agrawal

Thesis Title: "Signatures of Seesaw Models at Colliders"

8. **Mr. Amir Shee***

Advisor : Prof. Debasish Chaudhuri

Thesis Title: "Studies on Active Systems"

9. **Mr. Sayan Jana***

Advisor: Prof. Arijit Saha

Thesis Title: "Zero-energy modes and strong correlation effects in topological systems"

1.4 Conferences/ Workshops organized by IOP

International Conference on Nanostructuring by Ion Beams (ICNIB 2021)

6th International Conference on Nanostructuring by Ion Beams (ICNIB 2021) was organized by the Institute of Physics (IOP) Bhubaneswar, in collaboration with Inter University Accelerator Centre (IUAC), New Delhi, Indian Institute of Technology Bhubaneswar (IITBBS), National Institute of Science Education and Research (NISER) Bhubaneswar, and Ion Beam Society of India (IBSI). The meeting was held in online mode during 5 - 8 October 2021. The conference was co-chaired by Prof. Shikha Varma, IOP, Prof. T. Som, IOP, and Dr. Ambuj Tripathy, IUAC, New Delhi. The role of ion beams in nano-structuring and nano patterning has nucleated a research community which is intensely involved in the investigations related to the synthesis and modification of the surfaces and nanoparticles. The main motivation behind this conference series was to bring together active researchers in the field from all over the world to present and discuss their recent results. The previous conferences in the series were organized at University of Allahabad (in 2011), University of Rajasthan, Jaipur (in 2013), Agra (in 2015), Devi Ahalya Vishva Vidyalaya, Indore (in 2017), and Indira Gandhi Centre for Atomic Research, Kalpakkam (in 2019). The conference provided an engaging platform for scientists and scholars to discuss a host of topics involving ion beam induced synthesis, modification of nanostructures and radiation damage.

International Meeting on Effective Pathways to New Physics (IMEPNP)

The High Energy Physics Group of Institute of Physics (IOP, Bhubaneswar) organised an international conference 'International Meeting on EFFECTIVE PATHWAYS TO NEW PHYSICS (IMEPNP)' during February 7th-12th, 2022 at Institute of Physics, Bhubaneswar, India in the hybrid mode (in-person/online event). The workshop was organised with the objective to discuss the current status and future prospects of few different topics of Beyond the Standard Model Physics such as New Physics (NP) at Colliders, Higgs and Top Physics, Neutrino, Falvour Physics, and Astroparticle physics from the perspective of an Effective Field Theory (EFT) Framework. There were few pedagogical lectures and plenary talks by experts in each area reviewing the status of the field followed by more specific and technical talks presenting the latest work and developments in the field, along with dedicated discussion sessions. The organisers were Pankaj Agrawal, Manimala Mitra, Aruna Kumar Nayak, Debottam Das, Kirtiman Ghosh,

Sanjib Kumar Agarwalla, and Ajit Mohan Srivastava from the group.

The different topics that have been covered are Higgs and top physics, Neutrino Physics, Dark matter and other astroparticle phenomenology, Flavour physics, precision tests and Top-down approach of EFT with different Beyond Standard Model theories.

All together 237 participants participated in the conference, with majority of the participation via online mode. The conference started from 7th February, afternoon 14.00 IST with an inaugural ceremony by the IOP director Prof. K. K. Nanda, followed by pedagogical lecture by Prof. Clifford Peter Burgees (McMaster University and Perimeter Inst. Theor. Phys., Canada), review talk by Prof. Luca Silvestrini (INFN, Rome, Italy), Dr. Eleni Vryonidou (University of Manchester, UK). In the subsequent days, there were lectures by Prof. Kaladi Babu (Oklahoma State University, USA), review talk by Prof. Martin Hirsch (IFIC, Valencia, Spain), lecture by Prof. Michael Robert Trott (Niels Bohr Institute, Denmark), Prof. Tim M.P. Tait (UC Irvine, USA), Prof. Adam Falkowski (ORSAY LPT, France), talk by Dr. Subhaditya Bhattacharya (IIT Guwahati, India), Dr. Joydeep Chakrabortty (IIT Kanpur, India), Dr Sudeep Jana ((Heidelberg, Max Planck Inst.) and Dr. Ambresh Shivaji (IISER Mohali, India). The concluding talk has been delivered on 12th February at 4 pm by esteemed physicists Prof. John Ellis (University of London, UK). The conference was a major success amidst the pandemic time, as everyday more than 150 participants attended the meeting, including local participation from IOP of 22 participants.

RESEARCH

2.1. Theoretical High Energy Physics

Faculty members of the Theoretical High Energy Physics group at IOP (THEP@IOP) are working on cutting edge research areas like string theory, Cosmology, astrophysics, Quark-Gluon Plasma, Relativistic Heavy-Ion Collisions, neutrino oscillation, and dark matter experiments, and last but not least, collider phenomenology of different beyond the Standard model scenarios in the context of the ongoing Large Hadron Collider (LHC) and proposed electron-positron collider experiments. The significant research outputs of THEP@IOP during the academic year 2021-22 are in the following.

Prof. A. M. Srivastava and collaborators studied the modification of pulses from a pulsar arising from the effects of phase transition-induced density fluctuations on the pulsar moment of inertia. They showed specific patterns in the perturbed pulses, which are observable in modulations of pulses over large time periods. Prof. Srivastava and collaborators studied Hawking radiation from acoustic black holes in the hydrodynamic flow of electrons. They showed that Hawking radiation should be observable in terms of current fluctuations. Prof. Srivastava also worked on the possibility of probing the shapes of microbes using liquid crystal textures. Prof. Pankaj Agrawal's research focused on measuring Higgs boson (H) self-couplings and Higgs couplings to the W/Z (V) bosons at the high-energy Large Hadron Collider (LHC) experiment. Prof. Agrawal and collaborators considered double-Higgs and associated production mechanisms at the LHC and the FCC-hh to determine the VVH and VVHH couplings. Prof. Sudipta Mukherji and collaborators were involved in a holographic study of field theory on time-dependent background with the conical defect. In another project, Prof. Mukherji and collaborators obtained a general form of entropy correction to black holes resulting from the thermal fluctuations and fluctuations of its thermodynamic volume around the equilibrium. They then used the result to compute entropy corrections for a large variety of black holes in anti-de Sitter space-time. Prof. S.K Agarwala's research emphasizes exploring the fundamental properties of massive neutrinos. Some of the significant results from Prof. Agarwala's research group are (i) Identifying novel methods to resolve pressing issues like neutrino mass ordering, mixing angles, CP violation in the lepton sector, etc. (ii) Exploring the possibility of utilizing neutrino oscillations in the presence of Earth's matter to extract information about Earth's internal structure, density profile, and composition complementary to seismic and gravitational measurements. (iii) Investigating the possibility of indirect detection of dark matter through their annihilation or decay to neutrinos. Prof. Agarwala is also actively involved in the physics simulation studies related to the India-based Neutrino Observatory (INO) project. Prof. S. Banerjee's research is focused on understanding the relationship between asymptotic symmetries and scattering amplitudes in asymptotically flat space times. They showed that a certain class of graviton and gluon scattering amplitudes could be calculated based on asymptotic symmetries only. Dr. D. Das addressed issues like the magnetic moments of

charged leptons, charged lepton flavor violations, dark matter, neutrino mass/mixing, etc. in a simple extension of the Standard Model (SM) with an additional pair of vector-like lepton doublets and a scalar doublet. The prime objective of Dr. Manimala Mitra's ongoing research is to understand nature at the fundamental level. Her research addresses a few major questions of modern particle physics, the origin of neutrino masses and mixings, and the abundance of dark matter in the Universe. In recent work, Dr. Mitra and collaborators explicitly showed how proper implementation of the quantum statistics in dark matter relic density calculation in gauged B-L model might change the Maxwell-Boltzmann prediction for relic density significantly. The primary mission of Dr. Kirtiman Ghos's research group is to study the phenomenology of different BSM scenarios in the context of collider and other (neutrino scattering and oscillation, Dark Matter direct/indirect detection, lepton flavor violation, etc.) experiments and understand the complementarity between then. Dr. Ghosh mainly focused on the signatures of seesaw models at the collider experiments.

(A.M. Srivastava, P. Agrawal, S. Mukherji, S. K. Agarwalla, S. Banerjee, D. Das, M. Mitra, K. Ghosh)

QGP and Relativistic Heavy-Ion Collisions:

1.(a) Initial fluctuations and power spectrum of flow anisotropies in relativistic heavy-ion Collisions.

Flow coefficients in relativistic heavy-ion collisions are a crucial probe of initial state fluctuations arising from the parton distributions of the colliding nuclei. This has a very strong correspondence with the physics of power spectrum of cosmic microwave background radiation (CMBR) anisotropies which directly probes initial inflationary fluctuations. We present a short review of these developments. The effect of initial magnetic field on these features will also be reviewed.

(Shreyansh S. Dave, Saumia P.S., and Ajit M. Srivastava)

(b) Modulation of pulse profile as a signal for phase transitions in a pulsar core

We calculate detailed modification of pulses from a pulsar arising from the effects of phase transition induced density fluctuations on the pulsar moment of inertia. We represent general statistical density fluctuations using a simple model where the initial moment of inertia tensor of the pulsar (taken to be diagonal here) is assumed to get random additional contributions for each of its component which are taken to be Gaussian distributed with certain width characterized by the strength of density fluctuations. We show that there are very specific patterns in the perturbed pulses which are observable in terms of modulations of pulses over large time periods.

(*Partha Bagchi, Biswanath Layek, Anjishnu Sarkar, and Ajit M. Srivastava)*

(c) Hawking radiation from acoustic black holes in hydrodynamic flow of electrons

Acoustic black holes are formed when a fluid flowing with subsonic velocities, accelerates and becomes supersonic. When the flow is directed from the subsonic to supersonic region, the surface on which the normal component of fluid velocity equals the local speed of sound acts as an acoustic horizon. Here we investigate this possibility in the hydrodynamic flow of electrons. Resulting Hawking radiation in this case should be observable in terms of current fluctuations. Further, current fluctuations on both sides of the acoustic horizon should show correlations expected for pairs of Hawking particle.

(*Shreyansh S. Dave, Oindrila Ganguly, Saumia P.S., and Ajit M. Srivastava)*

(d) Probing shapes of microbes using liquid crystal textures

Assuming certain anchoring conditions for the NLC director at the surface of the microbe, we determine the resulting shapes of brushes using numerical simulations. Our results suggest that for asymmetrical microbes (such as cylindrical shaped bacteria/viruses), resulting brushes may carry the imprints of this asymmetry (e.g. the aspect ratio of cylindrical shape) at large distances to be able to be seen using simple optical microscopy, even for microbe sizes in few tens to few hundred nanometer range. For more complicated shapes, such as spiral shape bacterias or Filovirus such as Ebola viruse, even the topology of brushes may be non-trivial depending on the spiral nature/folding of the virus along its length. For roughly spherical microbes, such as the corona virus, information

about the size of the virus may possibly be probed using brush deformations near the core in the presence of external electric/magnetic field.

(Ajit M. Srivastava)

2.(a) Measurement of VVHH coupling at hadron colliders

Although the Higgs boson has been discovered, its coupling to the W/Z bosons still needs to be constrained. We are considering the double-Higgs production through the VBF and associated production mechanism at the LHC and the FCC-hh to determine the VVH and VVHH couplings. Our current focus is how these couplings are modified when we have extended Higgs sector with more scalar singlets, doublets, and triplets. We are using machine learning techniques to put bounds on the couplings in this extended scalar sector models.

(Debashis Saha, Ling-Xiao Xu, Jiang-Hao Yu, C.-P. Yuan)

(b) Electroweak Corrections to H→VV

In this project, we are computing the electroweak corrections to the decay process $H \to VV$. Here V boson can be a W or Z boson. The one-loop diagrams have the VVHH coupling. There are large numbers of complicated diagrams. We have computed these diagrams. We are studying the effect of modifying HHH and VVHH coupling on the decay width. This can help in determining these couplings.

(Pankaj Agrawal, Biswajit Das)

3. Conical Space-time and AdS/CFT: We initiate a holographic study of field theory on time dependent background with conical defect. We focus on the Milne space-time to which, in the absence of cosmological constant, at late time any hyperbolic Friedmann- Robertson – walker metric flows to. When the milne vacuum is represented by the adiabatic one, we are able to compute the two point correlators of operators which are dual to massive scalars in the bulk AdS-Milne background with defect. We find for both twisted and untwisted operators, the correlates can be represented as the sum over images. The sum can be carried out explicitly to write the results in compact forms (with Swayamsida Mishra & Yogesh Srivastava, arXiv: 2205.14080).

Entropy correction to black holes: within the framework of extended thermodynamics, black hole entropy is expected to receive corrections from thermal fluctuations as well as fluctuations of its thermodynamic volume around equilibrium. Working in the isothermal – isobaric ensemble with the cosmological constant playing the role of a barostat, we find the general form of these corrections. The results is them used to compute entropy corrections for a large variety of black holes in anti-de Sitter Space- time (with Aritra Ghosh & Chandrashekhra bhamidipati, arXiv: 210412770, arXiv: 2104.12720)

(Sudipta Mukherji)

4. My area of research is High Energy Particle Physics with main emphasis on exploring the fundamental properties of massive neutrinos. We have made several outstanding contributions in neutrino physics. To name a few:

(a) Studied the role of high-energy astrophysical neutrinos detected by IceCube to unravel new fundamental particles and interactions,

probing energy and distance scales far exceeding those accessible in the laboratory.

(b) Contributed significantly in identifying novel methods to determine the neutrino mass ordering, mixing angles, and CP-violation in the lepton sector, all of which are pressing fundamental unsolved issues.

(c) Playing an important role to study the impact of a light eV-scale sterile neutrino, non-standard neutrino interactions, Lorentz invariance violation, and non-unitary neutrino mixing in oscillation experiments.

(d) Exploring the possibility of utilizing neutrino oscillations in the presence of Earth's matter to extract information about the internal structure, density profile, and composition of Earth complementary to seismic and gravitational measurements.

(e) Investigating the possibility of indirect detection of dark matter through their annihilation or decay to neutrinos.

(f) Actively involved in the physics simulation studies related to the India-based Neutrino Observatory (INO) project. Several INO Ph.D. students are getting trained under my supervision.

(g) Playing an important role to provide a rigorous test of the three-flavour neutrino oscillation paradigm and to explore the landscape of beyond the Standard Model (BSM) physics in the context of the upcoming high-precision long-baseline experiments such as DUNE in USA and T2HK in Japan.

(S.K Agarwalla)

5. My research work is focussed on understanding the relation between asymptotic symmetries and scattering amplitudes in asymptotically flat space times. In this work one of our major achievements is to show that a certain class of graviton and gluon scattering amplitudes can be calculated based on asymptotic symmetries only. This is a novel technique and a clear hint that quantum theory of gravity in asymptotically flat space times are holographic in nature. I wish to pursue this line of research in future.

(S. Banerjee)

6. Magnetic Moments of Leptons, Charged Lepton Flavor Violations and Dark Matter Phenomenology of a Minimal Radiative Dirac Neutrino Mass Model: In a simple extension of the standard model (SM), a pair of vector like lepton doublets and a scalar doublet (η) have been introduced to help in accommodating the discrepancy in determination of the anomalous magnetic moments of the light leptons, namely, e and μ. Moreover, to make our scenario friendly to a Dirac like neutrino and also for a consistent dark matter phenomenology, we specifically add a singlet scalar (S) and a singlet fermion (ψ) in the set-up. However, the singlet states also induce a meaningful contribution in other charged lepton processes. A discrete symmetry Z_2 Z'_2 has been imposed under which all the SM particles are even while the new particles may be assumed to have odd charges. In a bottom-up approach, with a minimal particle content, we systematically explore the available parameter space in terms of couplings and masses of the new particles. Here a number of

observables associated with the SM leptons have been considered, e.g., masses and mixings of neutrinos, (g -2) anomalies of e, μ, charged lepton flavor violating (cLFV) observables and the dark matter (DM) phenomenology of a singlet-doublet dark matter. Neutrinos, promoted as the Dirac type states, acquire mass at one loop level after the discrete Z'_2 symmetry gets softly broken, while the unbroken Z_2 keeps the dark matter stable. The mixing between the singlet ø and the doublet vector lepton can be constrained to satisfy the electroweak precision observables and the spin independent (SI) direct detection (DD) cross-section of the dark matter. In this analysis, potentially important LHC bounds have also been discussed.

(Debottam Das)

7. Dr. Manimala Mitra works in theoretical High Energy Physics. The prime objective of her ongo-ing research is to understand nature at the fundamental level. Her research works address few of the major questions of modern particle physics, origin of neutrino masses and mixings, and dark matter abundance of the Universe. The research works connect few of the most prominent areas of High Energy Physics, which are Neutrino Physics, Dark Matter, and Beyond the Standard Model Physics (BSM physics).

Her recent research works published in between April, 2021- March, 2022, with her students, postdoc and collaborators focus on few different beyond standard model theories and associated dark matter and neutrino phenomenologies. One of them is the extended gauged B-L model *JHEP* 05 (2021) 150 to explain dark matter relic density where thermal mass correction of the scalar have been taken into account. In this work, which Dr. Mitra has authored with her student Abhishek Roy, they explicitly showed how a proper implementation of the quantum statistics in dark matter relic density calculation in gauged B-L model may change the Maxwell-Boltzmann prediction for relic density significantly. The other significant work on dark matter is Phys.Rev.D 104 (2021) 5, 055047, where the effect of dimension-5 operator including right handed neutrinos (RHN) on DM phenomenology have been explored. The authors have explored the correlation between the vev of the gauge singlet scalar field which translates as mass of the BSM Higgs, and the mass of the DM. The tight correlation arises due to relic density constraint. In the absence of any bare mass term of the RHN, we find that, for the TeV scale vev of the BSM scalar, which is a natural choice for TeV scale or lower BSM Higgs states, the DM relic density constraint is satis-fied only if its mass is in the KeV range. This tight correlation relaxes if bare mass terms of RHNs is present in the Lagrangian. The authors have furthermore explored the constraints from the light neutrino masses in this set-up.

The other significant works are Phys.Rev.D 105 (2022) 3, 035001, and JHEP 09 (2021) 162. In the first work, Dr. Mitra and her collaborators explored lepton number violating neutrinoless double beta decay in the presence of RHNs. They have shown the eV-MeV scale RHNs in an alternate Left-Right symmetric model and extended seesaw model can have a large impact on the predic-tion of neutrino less double beta

decay. In another work JHEP 09 (2021) 162, the authors explored the effect of one additional sterile neutrino on neutrino oscillation.

Finally, in the recent work Phys.Rev.D 104 (2021) 1, 015002 with her postdoc Dr. Dibyakrupa Sahoo, a novel search strategy to investigate spin-parity of muon-philic X boson has been implemented.

(M. Mitra)

8. The primary mission of our research group (consisting of me and my Ph.D. students: Avnish, Vandana Sahdev, Saiyad Ashanujjaman, and Rameswar Sahu) is to study the phenomenology of different BSM scenarios in the context of collider and other (neutrino scattering and oscillation, Dark Matter direct/indirect detection, lepton flavor violation, etc.) experiments and understand the complementarity between then. We have contributed to the development and phenomenology of different BSM scenarios during 2021-22. A brief account of the important outcomes of our research is given in the following.

(a) The type-III see-saw seems to explain the very minuteness of neutrino masses readily and naturally. The high-energy see-saw theories usually involve larger number of effective parameters than the physical and measurable parameters appearing in the low-energy neutrino phenomenology. Casas-Ibarra parametrization facilitates to encode the information lost in integrating the heavy fermions out in an arbitrary complex orthogonal matrix. We reinterpret a CMS search in the context of a realistic type-III see-saw model with two or three generations of triplet fermions and endeavor to comprehend the implications of the foregoing matrix on the 95% CL lower limit on the mass of the triplet fermions. We also discuss the phenomenological implication of the aforesaid matrix in view of charged lepton flavor violating observables and displaced decays of the triplet fermions at colliders. We also proposed a search for the triplet fermions in final states with multiple leptons and fat-jets that are cleaner than the usual LHC searches and allow kinematic reconstruction of the triplets.

(b) Exotic leptons in large gauge multiplets, appearing in many scenarios beyond the Standard Model (SM), can be produced at the LHC in pairs or in association. Owing to their large masses, their eventual decay products — SM leptons and bosons — tend to be highly boosted, with the jets stemming from the SM bosons more likely to manifest themselves as a single fat-jet rather than two resolved ones. With the corresponding SM backgrounds being suppressed, final states with two or three leptons and one or two fat-jets are expected to be sensitive in probing exotic fermions much heavier than 1 TeV, and we propose and investigate an appropriate search strategy. To concentrate on the essential, we consider extensions of the SM by leptonic multiplets of a single kind (triplets, quadruplets or quintuplets), bearing in mind that such simplified models typically arise as low-energy limits of more ambitious scenarios addressing various lacunae of the SM.

(c) The type-II see-saw mechanism based on the annexation of the Standard Model by weak

gauge triplet scalar field proffers a natural explanation for the very minuteness of neutrino masses. Noting that the phenomenology for the non-degenerate triplet Higgs spectrum is substantially contrasting than that for the degenerate one, we perform a comprehensive study for an extensive model parameter space parametrized by the triplet scalar vacuum expectation value (VEV), the mass-splitting between the triplet-like doubly and singly charged scalars and the mass of the doubly charged scalar. We derive the most stringent 95% CL lower limits on the mass of the doubly charged scalar for a vast model parameter space by implementing already existing direct collider searches by CMS and ATLAS. Strikingly, we also find a specific region of the parameter space that is beyond the reach of the existing LHC search strategies.

(Kirtiman Ghosh)

2.2. Theoretical Nuclear Physics

We have worked on different areas of nuclear physics, such as finite nuclei, nuclear matter, and neutron stars. Starting from the finite nuclei, we mainly explore the properties such as nuclear structure and reaction dynamics of different atomic nuclei. Some of the structural properties, such as binding energy, charge radius, magic numbers, two-neutron separation energy, symmetry energy, etc., in detail, have been calculated. Nuclear reactions, including alpha and beta decays, clusterization, fissions, etc., were determined with the help of relativistic to non-relativistic energy density functionals.

The nuclear matter properties such as binding energy per particle, energy density, pressure, effective mass, symmetry energy, and its different coefficients, etc., in different environments, either in the presence of dark matter or temperature from very low density to high density. The nuclear matter, finite nuclei, and neutron star equation of states are calculated with the well-known relativistic mean-field (RMF) model. We have developed our two functionals such as G3 and IOPB-I and applied them from finite nuclei to the neutron star. Our extended RMF model well reproduced the properties of different systems, such as finite nuclei to the neutron star.

Recently, we have extended our domain and explored the neutron star properties by adding dark matter. Some of these neutron star properties, such as its equation of states, mass, radius, tidal deformability, the moment of inertia, cooling scenario, inspiral properties of the binary neutron star, oscillations properties, different curvature parameters, etc. are calculated. Also, we have added temperature to see its effects on the thermal conductivity, emissivity, specific heat, thermal index, etc. are computed with different fractions of dark matter inside it.

The gravitational wave properties are also explored using the post-Newtonian method for different masses of the binary neutron star. In the inspiral stage, some well-known properties such as frequency, polarisability, phases of the two binary, etc., have been calculated for dark matter admixed neutron stars.

Another method known as Coherent Density Fluctuation Model (CDFM) is applied by our group to calculate the surface properties of finite nuclei as well as of Neutron Star. Here, we evaluate the symmetry energy, neutron pressure and there surface properties.

(S. K. Patra, P. K. Sahu)

1. My research work involves on Nuclaer Physics Theory and Nuclear Astrophysics. I have published several papers in Theoretical Nuclear Physics and Nuclear Astrophysics, such as: (a) Nuclear Equation of States and determination of Gravitational waves from binary neutron stars merger (b) Study of nuclear fission for neutronrich nuclei (c) Nuclear structure and Cluster radioactive-decay (d) Structures of exotic and superheavy nuclei (e) Nuclear Giant resonances for both stable and unstable nuclei (f) Nuclear reaction study (g) Nuclear High Spin states (Nuclear spectroscopy) (h) Construction of both relativistic and non-relativistic nucleon-nucleon interactions (i) Study of surface properties using a recently developed Coherent Density Fluctuation Model (CDFM).

(S. K. Patra)

2. Relativistic interacting Hadron-Resonance Gas model.

The meson exchange interaction based on relativistic mean-field (RMF)theory has been introduced in the hadron resonance gas (HRG) model, called interacting HRG (iHRG) model. This model can be used to explain the experimental data both at finite temperature (T) with finite chemical potential (μB) and finite temperature at vanishing chemical potential. The nuclear matter equation of state also can be explained at zero temperature with finite baryon density (finite chemical potential) due to the presence of attractive and repulsive interactions between the hadrons in the iHRG model. Results from this study are compared with results from other heavy-ion transport models and experimental data.

The Fermionic dark matter inside the neutron star.

We study the Fermionic dark matter inside the neutron star, which couples to nucleons through Higgs field via effective Yukawa coupling. The neutron star matter is consists of leptons, nucleons and hyperons in the relativistic chiral sigma model. If the dark matter composition is increased then the neutron star gets more compact and hence the size and mass reduce significantly.

(P. K. Sahu)

2.3. Experimental High Energy Physics

The experimental high energy physics group at IOP participates in several leading collider based particle physics experiments in the world, such as CMS and ALICE experiments at LHC (CERN, Switzerland), STAR experiment at RHIC (BNL, USA), CBM experiment at FAIR (GSI, Germany).

The CMS group is making major contributions to the measurement of Higgs boson properties, which was discovered by the ATLAS and CMS experiments at LHC in 2012, using proton-proton collision data at centre-of-mass energy of 13 TeV. In particular, the contributions were made to the measurement of Higgs boson to top quark coupling by studying the production of Higgs boson in association with a pair of top quarks and decaying to a pair of tau leptons. The result of the analysis in all multilepton final states provides an observed significance of close to 5 standard deviations. The group made leading contributions to the measurement of Higgs boson CP properties in its decay to a pair of tau leptons, where the angle between the decay planes of the two tau leptons is employed as the discriminator to distinguish between different CP states. The result of the analysis with full 13 TeV data constrains the CP mixing angle to less than 20 degrees and excludes a pure CP-odd state by approximately 3 standard deviations. Furthermore, the group is involved in the analysis for the search of a charged Higgs boson decaying to a charm and a strange quark, where the charged Higgs originates from the decay of a top quark, which provides stringent exclusion limit on this branching ratio obtained with analyzing the 13 TeV data. In addition, the group contributed to the development and performance measurement of tau, jet, and missing energy triggers. It also developed a microTCA based test setup for functional test of CMS silicon-strip tracking detector modules, in collaboration with the CMS tracker group.

The heavy ion physics group is involved in studying several phenomena in the relativistic heavy nucleus collisions and proton-nucleus collisions. It has studied the production of $\Lambda(1520)$ resonance at ALICE in p-p and p-Pb collisions at 7 TeV and 5.02 TeV, respectively. This measurement may help models to have an upper bound on the hadronic scattering medium in p-Pb collisions at 5.02 TeV. It has also performed several studies on theoretical models, such as application of Nilsson model for deformed nucleus, study of strange and non-strange hadron production and ratios in pp and p-Pb collisions at LHC energies, and relativistic interacting Hadron-Resonance Gas model. Furthermore, the group is carrying out R&D on the Gas-Electron-Multipliers (GEM) detector. It has performed the characterizations of a prototype using the x-rays emitted from the metal targets by hitting the proton beam at the ion beam facility of Institute of Physics. It performed a systematic investigation of ion backflow fraction of quadruple GEM detector and also performed simulation study of its properties using Garfield++ simulation package. Moreover, it is developing a high voltage control system for the MUCH detector in CBM experiment.

(P. K. Sahu, A. K. Nayak)

1. Characterizations of GEM detector prototype

Gas Electron Multipliers (GEM) detector possess high rate capability and high resolution as compared to the detector based on the wire chamber or tracking drift chamber principle.

A Triple-GEM prototype of area 10$ \times$ 10 cm^2 was fabricated and characterized using Fe^{55} source at Institute of Physics, Bhubaneswar. We used the same GEM detector to characterize by using the ion beam facility at Institute of Physics. Proton beam generated from a 3MV Tandem Pelletron was used to emit X-rays from different metal targets to study the characteristics of GEM detector. X-rays yield of the metal (Fe) is directly proportional to the proton beam current. Anode current (nA) and gain as a function of GEM voltages at different beam current have been studied and were found exponentially increases with GEM voltage, which was uniform.

Ion Backflow fraction of quadruple GEM detector

A systematic investigation is done for the study of ion backflow fraction with GEM based detectors. The ion current along with detector gain is carefully measured in various voltage configurations and with different gas proportions. The main idea is to optimize the detector for the lowest ion backflow current. For that a detailed scan over drift and induction field is done with varying gas ratio. A minimum ion backflow fraction of 3.5$\%$, 3.0$\%$, 3.8$\%$ is obtained with drift field 0.1kV in Ar:CO$_2$ gas in 70:30, 80:20 and 90:10, ratios respectively.

Simulation:

For Characterization of detector, initiative is taken for doing numerical analysis with Garfield++ simulation package. The simulations include measurements of detector Gain, Transparency, Efficiency, Ion backflow and signal extraction etc. ANSYS scripts, based on finite element method is used to model different geometries and configurations of GEM prototype and for the calculation of electric field inside the detector volume. Here, we made a simulation study on stacks of 4-GEM to characterize the properties like gas gain, effective gain, transparency, ion backflow, energy and position resolution using Garfield++ and ANSYS field solver.

(P. K. Sahu)

2. Physics analyses using pp collision data recorded by the CMS experiment at CERN-LHC at centre-of-mass energy of 13 TeV

The IOP-CMS group has made major contributions to the measurement of Higgs boson CP properties in its decay to a pair of tau leptons. The Higgs boson in the SM is expected to have a CP quantum number of +1 (CP even state). However, various BSM models predict additional Higgs bosons, including the ones that can be CP odd (CP=-1) or a mixture of the two (not a CP eigen state). The angle between the decay planes of the two tau leptons is a suitable observable to discriminate between the CP odd and CP even states as well as between CP eigen and CP mixture states. The decay planes are constructed from charged pion momentum and its impact parameter with respect to primary vertex or using the momentum of both charged and neutral

pions, depending on the tau lepton decay modes. The analysis with full Run-2 data at 13 TeV CoM energy provides a measured value of the CP mixing angle to be (-1 +/- 19) degree at 68% confidence level and excludes a pure CP-odd state by 3 standard deviations.

In addition, we are leading an analysis for the search of a charged Higgs boson decaying to a charm and a strange quark, where the charged Higgs originates from the decay of a top quark. The analysis involves kinematic fitting to fully reconstruct the top quark pair and multivariate methods to discriminate signal from backgrounds. We are also involved in the analysis for the search for a pseudo-scalar Higgs boson that can decay to a Z boson and the Standard Model like Higgs boson. The final state consists of two leptons (electron/muon) from Z decay and two tau leptons from Higgs decay. The analysis is being performed with full available 13 TeV data collected during 2016 to 2018. Furthermore, we are involved in the effort for the measurement of branching ratio for Bs meson decaying to a pair of tau leptons. This decay process is very rare in the Standard Model (Br ~ 10^{-9}).

Contributions to the development of high-level trigger and detector upgrade in the CMS experiment

We are involved in the development of CMS high-level trigger system for LHC Run-3, which is starting from 2022. We are involved in leading the STEAM group under Trigger Coordination for last two years. And, we have been consistently performing trigger rate studies for last one year using some high instantaneous luminosity data collected during 2018 runs and have developed various analysis framework for this purpose. We have also been leading the development of tau reconstruction and identification at the HLT level and development of tau HLT paths, and performed the measurement of Jet and Calorimeter Sum trigger efficiencies in Run-2 data. India-CMS is going to contribute significantly to the phase-II upgrade of the CMS detector for HL-LHC. Towards this effort, we are assembling a silicon-strip tracker detector module functional test set up, which will be used to test the modules during their assembly.

(A. K. Nayak)

2.4 Quantum Information

The quantum information group has been working in the area of foundations of Quantum Mechanics, Quantum Entanglement, Quantum Non locality, Quantum Communication protocols, and Quantum Cryptography. One of the areas of interest has been uncertainty relations for a composite system that incorporate a measure of entanglement. These relations can be useful for detecting, or measuring entanglement. In addition such relations can be used to ensure the security of some of the cryptographic protocols. We have proposed Inferred-variance uncertainty relations to serve these purposes.

One of the problems faced in the practical implementation of Quantum Communication protocols and Quantum Computing Algorithms is the noise. Interaction of a quantum system with the environment makes its state fragile. This can reduce the efficacy of the protocol or algorithm quite severely. This fragility of the state is a major obstacle in the development of practical devices. One way to reduce the impact of the noise is quantum error corrections. We have studied and proposed methods to use path-polarization entanglement for error corrections.

(P. Agrawal)

1. Quantum Error Correction and Path-polarization Entanglement

One of the problems that is faced in real life quantum information processing tasks is the presence of noise. The noise makes the development of a realistic quantum computer or communication system more daunting. Quantum error correction codes have been introduced to tackle these situations. However, this process is resource intensive. For communication using photons, we have proposed quantum error correction protocols using path-polarization entanglement. This process requires fewer resources and is deterministic for many different kind of noises.

(Tanumoy Pramanik and Sayak Bhowmik)

2. A New Classification of Three-qubit Pure States

On the basis of SLOCC paradigm, three-qubit pure entangled states are classified in two classes: W-states and GHZ-states. But this classification is not useful from quantium communication protocol perspective. For example, there are GHZ-class states that are not suitable or teleportation, but W-class states are. Here key property of a state is von Neumann entropy of individual qubits. We have proposed a classification on this basis and demonstrated its usefulness using a multitude of quantum information processing protocols, including Bell violation, telepotation, and cryptography.

(Sk. Sazim, P. Agrawal)

2.5 Experimental Condensed Matter Physics

The Experimental Condensed Matter Physics Group at IOP has active research programs in a wide range of areas including, accelerator based research activities, thin films, surface science, highly correlated electron systems, two-dimensional materials, quantum materials. Members of the group are also exploring advance functional materials for solar cell, memory and sensor applications. Our main goal is to investigate and understand the structure and properties of solids. We use different techniques such as ion implantation, pulsed laser deposition, molecular beam epitaxy and high temperature solid state reaction to prepare high quality novel materials. Various properties of the materials are investigated using sophisticated and advanced instruments that includes high resolution X-ray diffraction, transmission electron microscope, field emission scanning electron microscope, atomic force microscope, SQUID, physical properties measurement system, high resolution Raman spectrometer, Angle-resolved photoemission spectroscopy etc.

(S. Varma, T. Som, B. R. Sekhar, D. Topwal, S. Sahoo, D. Samal)

1. (a) Role of amine in the sequestration of Arsenic from water

The influence of arsenite (As (III)) adsorption on 3APPA organic layer has been investigated using X-ray photoemission spectroscopy, vibrational IR and Raman spectroscopy. The functional amino group on 3APPA appears to play a significant role in the adsorption mechanism. Results of a combined experimental and theoretical investigation provide a comprehensive picture of the geometry and vibrational properties of 3APPA monolayers after interaction with arsenite. 3APPA, as a functionalized bio-adsorbant, shows promise towards detection and remediation of Arsenic in contaminated wastewater. (Shikha Varma, IOP-BBSR, Peter Dowben and Rebecca Lai Univ. of Nebraska, Lincoln, USA)

(b) Tuning electronic behavior of Graphene Quantum Dots synthesized via ion irradiation

The tuning of the photoresponse and electronic structure for ion induced graphene quantum dots (GQDs), through variations in the ion irradiation processing of monolayer graphene, is demonstrated. Synthesis of nano-dimensional quantum dots (3–9 nm) was observed for graphene after irradiation at various energies. The photo-response from these quantum dots can be manipulated and significantly enhanced simply with the change of ion energy. The results display a method that can be useful in designing graphene quantum dot based photodetectors, in a single step process with ion irradiation, without incorporation of any metal-nanoparticles or hybrid-metal platforms. Changes in the UV absorbance are of immense significance having many potential applications in UV based detectors. (Shikha Varma, IOP-BBSR, Ashis Manna, IIT BBSR, Peter Dowben, Univ. of Nebraska, Lincoln, USA)

(c) Oxygen vacancy assisted condensation of DNA molecule

An exotic condensation of DNA molecules is observed on the nanostructured ZnO surface. This is reflected via the changes in the persistence length of the DNA molecules. Conformational changes also induce a reinforcement of the bonds, and binding in both phosphate and the base regions of the DNA with the positively charged vacancy sites on the surface get modulated. The strong interactions effectively reduce the end-to-end distance of the λ-DNA molecule. This suggests a transition of the λ-DNA molecule, through structural modification, into a more compact higher-order fractal. (Shikha Varma, IOP-BBSR, Subrata Majumder NIT Patna)

(d) Investigations of ZnMgO nanopowders

The compositional and structural disorder in ZnMgO leads to a non-linear decrease of the lattice constant with composition. The value of the positional parameters indicate an ionic character and the distortion in the Zn-O4 tetrahedra. Raman Spectroscopy measurements and PL studies have been utilized to investigate the phonon modes and bandgap properties. A one-mode behavior of the phonons is explained by a modified random element iso-displacement model. (Shikha Varma, IOP-BBSR, Shyama Rath, Delhi University)

(e) Properties of Multilayered Cobalt doped TiO2 thin films

Effect of multilayers (1, 3 and 7 layers) and cobalt doping on structural and optical properties

of TiO2 thin films have been investigated. X-ray diffraction and Raman spectroscopy measurements show the formation of single phase anatase TiO2 structure of the films. Development of cracks with increase in number of layers at large scale is also observed. Spectroscopic ellipsometry was used to study the optical constants like refractive index and extinction coefficient which indicate the highest refractive index and the lowest extinction coefficient for single layered cobalt doped TiO2 films while 7 layered films show the lowest refractive index and the highest transmittance. (Shikha Varma, IOP-BBSR, Anupama Chanda, Dr. Harisingh Gour Central University, Sagar)

(S. Varma)

2. (i) Growth of textured semiconductor substrates by chemical etching for anti-reflecting surfaces

This project focuses on the fabrication of chemically textured semiconductor substrates for achieving anti-reflecting surfaces. In our recent study, we have employed metal-assisted chemical etching (MaCE) at room temperature, leading to the formation of shell-shaped GeO_x islands on Ge substrates. Dimension of the GeO_x islands and their coverage on Ge substrates can be tuned by various etching parameters. The specular reflectance data of GeO_x-decorated Ge surfaces show up to ~28% reduction in the optical reflectance value compared to the pristine one. However, etchings performed at an elevated temperature leads to the formation of pyramidally textured-Ge substrates. Interestingly, the optical reflectance of pyramidally textured surfaces reduces to an unprecedented low value of 0.23% over a broad spectral range. (Alapan Dutta and Tapobrata Som)

(ii) Growth and characterization of thin films for career selective contact-based photovoltaic cells

This project aims at studying the growth and characterization of thin films of transparent conducting oxides, career-selective contacts, and other active layers needed to fabricate multi-junction hole-blocking photovoltaic cells. These include both bulk and local probe-based studies to optimize the growth of individual layers to achieve an optimal power conversion efficiency of a photovoltaic cell. At present the main thrust is on optoelectronic optimization of constituent layers including metal oxide contact for Sb_2Se_3-based photovoltaic cells. (Alapan Dutta, Aparajita Mandal, and Tapobrata Som)

Another project is to develop passivating contacts for thin film silicon solar cells. In this direction, we are exploring different metal oxides, such as ZnO:Al, ZnO:Cu, WO_3, and TiO_2 for their compatibility as a carrier selective passivating contacts to Si wafers. Growth of V_2O_5 thin films (by sputtering) and their characterizations were also performed utilizing local probe techniques. Computational studies were conducted utilizing SCAPS 1D software to investigate the metal oxide contact-based Sb_2Se_3 solar cells. Additionally, density functional theory simulation is used to explore few metal oxides such as TiO_2 and In_2O_3 using Quantum Espresso with the aim to investigate their structure-property relation. (Aparajita Mandal and Tapobrata Som)

(iii) Nanoscale emulation of bio-synaptic behaviour for neuromorphic computing

It is interesting to note that a fundamental element of the bio-brain is a synapse and a two-terminal memristor, known as "artificial synapse", can faithfully emulate the bio-brain features at device level. In one of the projects, by utilizing local probe techniques, we present a forming-free two-terminal memristive system (e.g. TiO_2), featuring long-term and short-term memories alongside the other essential bio-synaptic functionalities at nanoscale. We have also demonstrated that an artificial nanoscale nociceptor can be built upon using a gold ion implanted, two terminal forming-free TiO_x memristor. In another work, the essential bio-synaptic functions in ZnO:Cu memristors were accomplished by ultra-low write current (~10 nA) and in a forming-free approach that demonstrates the potential in building fast-learning and power-efficient computing systems. (Dilruba Hasina, Rupam Mandal, Aparajita Mandal, and Tapobrata Som)

(T. Som)

3. We work in interdisciplinary research areas of condensed matter science, namely quantum materials and hybrid perovskites. Combining an array of state-of-the-art experimental techniques and theoretical tools, our research activities are aimed at understanding the electronic and magnetic properties of various classes of transition metal compounds, thin films and self-assembled nanoscale systems. Our research interest also extends to various advanced functional materials like hybrid perovskites and semiconductor nanoparticles, which have potential technological applications and are projected as next-generation photovoltaics material.

- Understanding why $MAPbBr_3$ (MA= CH_3NH_3) an organic-inorganic lead halide, a new generation optoelectronic material is more stabe under ambient condition compared to $MAPbI_3$. We find relatively reduced value of linear coefficient of thermal expansion, elevated Einstein temperature, and reduced dynamic disorder in $MAPbBr_3$ compared to $MAPbI_3$, which implies that a relatively rigid Pb–Br bond offers steric hindrance to the migration of bulky CH_3NH_3 ion resulting in improved stability of $MAPbBr_3$.

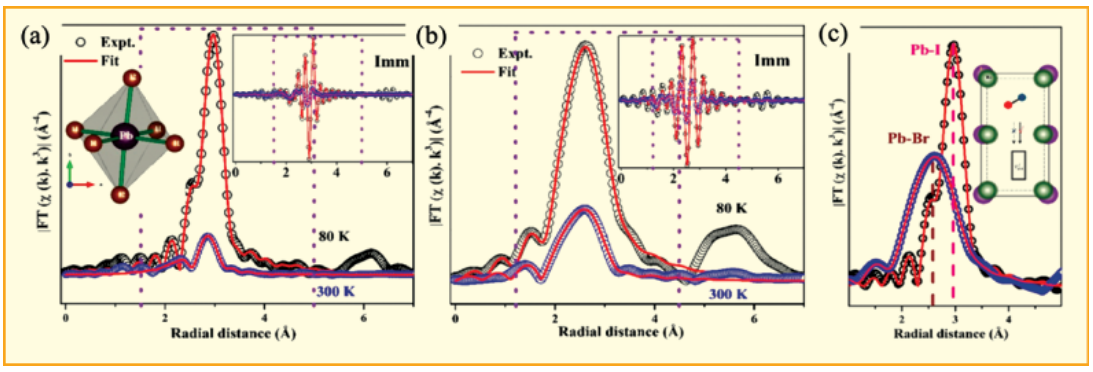


Fig: The moduli of Fourier transform of the EXAFS data (open circle) and the theoretical (solid red line) curves for samples (a) $MAPbI_3$ and (b) $MAPbBr_3$; the imaginary parts (Imm) are shown in the inset. (c) comparing the two.

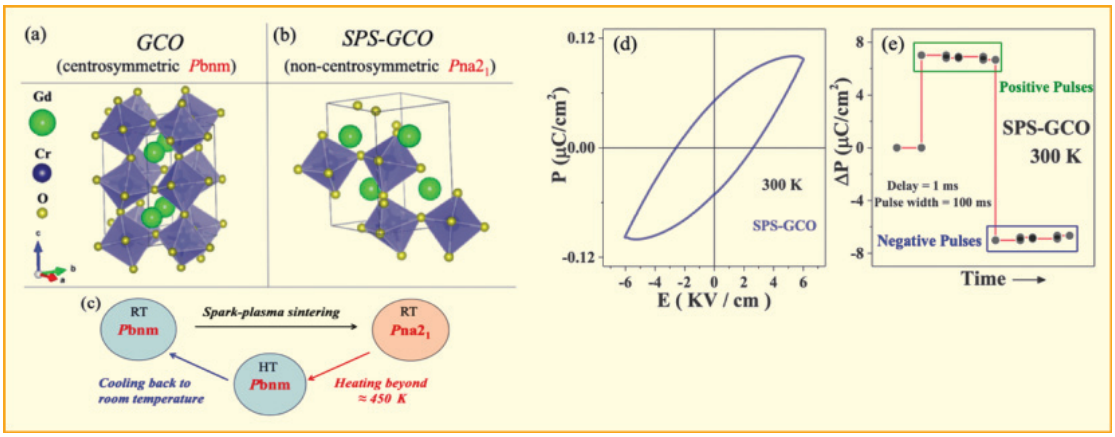


Fig: The unit cells corresponding to the (a) Pbnm and (b) Pna2$_1$ structures of $GdCrO_3$. (c) Schematic visualization of the room-temperature (RT) structural change from Pbnm (in GCO) to Pna2$_1$ (in SPS-GCO) after the spark-plasma sintering process. Upon heating beyond 450 K, this RT Pna2$_1$ phase gets converted to the high-temperature (HT) Pbnm phase, which upon subsequent cooling remains in the Pbnm phase. (d) Room-temperature electric polarization (P)–electric field (E) loop (collected at a frequency of 200 Hz) of SPS-GCO. (e) Room-temperature PUND data for the 6 kV/cm applied electric field on SPS-GCO.

- A spark-plasma sintered $GdCrO_3$ (SPS-GCO) stabilizes in ferroelectric phase beyond room temperature. This is in contrast to the concomitant antiferromagnetic and ferroelectric ordering observed below H"170 K in $GdCrO_3$ (GCO) prepared by solid state synthesis.

(D. Topwal)

4.(a) Electric Field-Modulated Charge Transfer in Geometrically Tailored MoX_2/WX_2 (X=S, Se) Heterostructure

Light-induced interlayer charge transfer in staggered-type heterostructures (HSs) in transition-metal dichalcogenides provides the opportunity to improve the performance of optoelectronic applications. In this work, density functional theory calculations are implemented to examine the evolution of band structures in MoS_2/WS_2 and $MoSe_2/WSe_2$ heterostructures with two different stacking geometries (AA and AA2) under vertical electric fields. The band-decomposed charge densities show that the interlayer coupling strength varies for different stacking geometries, leading to unequal interlayer spacings. The calculation shows that for an applied external negative electric field range (0 → -3 V/nm), cyclic band-alignment transition, i.e., from type-II to type-I to type-II, occurs in AA stacking. In contrast, a single transition from type-II to type-I occurs in AA2 stacking. The band alignments remain immune to applying positive electric fields for both the stacking geometries. MoS_2/WS_2 and $MoSe_2/WSe_2$ heterostructures experience the band-alignment transitions at lower electric fields as compared to the reported systems such as GaSe/GeS, α tellurene/MoS_2, and black phosphorous/MoS_2, which indicates the robust nature of our systems for low-power optoelectronics applications. The band inversion at critical field is found to arise by the spontaneous polarization of the heterostructures, and the value differs for different stacking geometries. The variation of

band offsets of the heterostructures is noticed to be higher with positive electric field than with negative field, which affects the charge separation/recombination time. Furthermore, it is observed that the charges are considerably localized at highsymmetry Γ points in MoS_2 and WS_2 layers at –3 and +3 V/nm, respectively, affecting the charge transfer through the interface. Finally, the possible pathways for photogenerated electron and hole transfer across the layers are explained by the selective excitations from both MoS_2 and WS_2. The strength and direction of electric fields are found to play critical factors in tuning the direct and indirect intralayer and interlayer excitons. Owing to the tunability of interlayer charge transfer by a vertical electric field, our findings are paramount in modulating electron-hole recombination and charge-transfer time, which is beneficial for future optoelectronic devices.

(J. Phys. Chem. C 2021, 125, 40, 22360–22369)

(b) Strain-mediated Ferromagnetism and Low-field Magnetic Reversal in Co-Doped Monolayer WS_2

Strain-mediated magnetism in 2D materials and dilute magnetic semiconductors hold multifunctional applications for future nano-electronics. In this work, we explore the strain-induced ferromagnetic properties of transition metal Co-doped WS_2 monolayer using first-principles DFT calculations and micromagnetic simulation. Co-doping marks a significant change in the magnetic properties of WS2, which further increases at low compressive (-2 %) and tensile (+2 %) strains. From the PDOS and spin density analysis, the opposite magnetic ordering is found to be favorable under the application of compressive and tensile strains. The magnetic exchange interaction is found to be double exchange coupling between Co and W and strong p-d hybridization between Co and nearest S. The spin density distribution also supports this argument. We find that the resultant impurity bands of the Co-doped WS_2 play a seed role in driving novel electronic and magnetic properties under applied strain. Furthermore, magnetic moments at higher applied strain decrease due to reduced spin polarization. In addition, the competition between exchange splitting and crystal field splitting of Co d-orbital plays a significant role in determining these values of magnetic moments under the application of strain. From an application point of view, we studied micromagnetic simulations to understand the ferromagnetic behavior of Co-WS2 monolayer. Micromagnetic simulation reveals that the ferromagnetic behavior calculated from DFT exhibits low-field magnetic reversal (190 Oe). Moreover, the spins of the Co-doped WS_2 monolayer are slightly tilted from the easy axis orientations showing a slanted ferromagnetic hysteresis loop. Our findings indicate that induced magnetism in WS_2 monolayer under Co-doping promotes the application of 2D TMDCs for the nano-scale spintronics, and especially, the strain-mediated magnetism can be a promising candidate for future straintronics applications.

(Scientific Reports 2022, 12, 2593)

(c) Multilevel resistive switching in graphene oxide-multiferroic thin-film-based bilayer RRAM device by interfacial oxygen vacancy engineering

A combination of 2D functional material and multiferroic Bismuth Ferrite can be introduced

into a unique multifunctional device due to its inherent properties at room temperature. In this work, we demonstrate a low-power operated ReRAM in GO-BFO heterostructure, which also shows multilevel characteristics. GO-BFO design provides an excess accumulation of oxygen vacancies at the interface and offers better memory capability than their pristine GO and BFO ReRAM. The conduction process in pure GO does not suffer more significant distortion when stacked to BFO. Both single-layer GO and bilayer GO/BFO heterostructure show similar conduction mechanisms, i.e. Ohmic behavior at low voltage region and space charge limited current conduction mechanism at higher voltage region to complete the resistive switching process. In GO RRAM, Ag^+ ion-induced conducting filament is primarily responsible for the switching process, while oxygen vacancies dominate in GO/BFO heterostructure. The appearance of intermediate resistive states under single voltage operation is one of the unique highlights of this work. Also, at least a four-state and three-state memory is demonstrated at a lower time scale in GO/BFO while tuning the pulse-width and pulse-height operation. Our findings suggest the possibility of ultrafast, multilevel RRAM for next-generation high-density memories and neuromorphic computing applications.

Applied Physics A 2022, 128, 1-11

(d) Electronic bandstructure modulation of MoX_2/ZnO(X:S, Se) heterostructure by applying external electric field

In this work, we studied the modulation in the electronic properties of heterostructures formed using transition metal dichalcogenides MoS2, MoSe2 and oxide-ZnO using density functional theory. The calculations are performed for the 2-Dimensional Van der Waals heterostructure of MX2(M: Mo, X:S, Se) and graphene-like ZnO under the external electric field (EF) applications ranging between -0.50 V/Å to 1.0 V/Å. The presence of an electric field precisely affects the band-alignment properties of these heterostructures. The bandstructure of MoS2/ZnO heterostructure (HS) shows an indirect bandgap of 1.61eV with a type-II band alignment and a large built-in electric field of 7.42eV with a valence band offset of 1.22eV across the interface. However, the bandstructure of MoSe2/ZnO shows a direct bandgap of 1.81eV with type-I alignment and a built-in electric field of 3.64eV with a band offset of 0.31eV. The heterostructure suffers a band re-alignment and bandgap modulation when the electric field is applied perpendicularly to the heterostructure. The energy bandgap increases linearly with the applied electric field for MoS2/ZnO (1.1–2.2eV) and remains almost constant (1.81eV) in the range -0.50V/Å to 0.50V/Å followed by a slight decrease with an increase in the electric field (1.60 for EF=±1.0V/Å). A cross-over in the bandgap type from indirect (type-II) '!direct (type-I) in MoS2-ZnO and direct (type-I) to indirect (type-II) in MoSe2/ZnO has been observed at a critical value of electric field EF = 0.75V/Å. The cross-over in band structure is consistent with the charge transfer pattern observed in the electric field application. Tuning the electronic bandgap and changing the band-alignment with an external electric field opens a way to design futuristic electronic and optical devices.

Surfaces and Interfaces A 2022, 29, 101817

(S. Sahoo)

5. Our work is focussed on elucidating the emergent electromagnetic phenomena in Designer Quantum Materials. Below, we summarise some of our research findings on complex oxide thin films.

A. Evidence for Spin-Orbit and e-e Coulomb Interaction from Magnetotransport Study on $CaCu_3Ru_4O_{12}$ thin films: $CaCu_3Ru_4O_{12}$ (CCRO) is considered as a d-electron-based heavy-fermion metallic system with intriguing electronic properties. The magnetotransport measurements on PLD grown metallic CCRO thin films reveal weak antilocalization (WAL) effects; however, it is not straightforward to infer whether the same originates from e-e Coulomb interaction (EEI), spin-orbit interaction (SOI), or both present in CCRO. By evaluating quantum correction to sheet conductance for CCRO metallic thin films in the two-dimensional limit, it is observed that SOI gives rise to a dominant contribution to negative magnetoconductance (MC) in the weak-field regime. Based on weak localization (WL) and WAL analysis, SOI and inelastic scattering lengths (lso and lö) are obtained to be 30 and 74 nm, respectively, which indicates that WAL (lso < *l*φ) remains at play. The anisotropic effect of SOI is reflected in the field-direction-dependent in-plane and out-of-plane MC measurements. The presence of the EEI contribution is evidenced from (i) the linear increment (positive slope) of sheet conductance with ln(T) in the quantum interference regime [only the WAL effect should otherwise show a negative slope with ln(T)] and (ii) ln(T) dependence of the Hall coefficient with a negative slope. Further, in the high-magnetic-field regime where WL or WAL is not valid, MC follows ln (B) type behavior, indicating the presence of EEI. Our findings have implications for the basic understanding of quantum magnetotransport properties in the presence of SOI and EEI in CCRO.

B. Tailoring magnetism in spinel vanadate CoV_2O_4 epitaxial thin films: Near itinerant cubic bulk CoV_2O_4 is at variance with other spinel vanadates by not showing orbital ordering down to low temperature, albeit it displays fragile anomalies related to spin, and lattice structure, signaling a spin/orbital glass transition around 95 K. We investigate tetragonal-like epitaxial CoV_2O_4 films on $SrTiO_3$ and $(La_{0.3}Sr_{0.7})(Al_{0.65}Ta_{0.35})O_3$ substrates that exhibit pronounced signature of spin reorientation transition from to a/b plane around 90 K unlike its bulk counterpart. Using in-plane and out-of-plane magnetic measurements, we demonstrate the intricate link between Co^{2+} and V^{3+} sublattice magnetizations that give rise to anisotropic magnetic switching. Further, we uncover the evidence for slow relaxation over a period of ~10^4 sec at 20 K and memory effect that indicates the possible existence for magnetic glassy phase in the low temperature regime. Using epitaxial strain as a control knob, our results inspire future study to manipulate orbital states, spin texture and itinerant electron character in tailored CoV_2O_4 films away from cubic lattice symmetry.

(D. Samal)

2.6. Theoretical Condensed Matter Physics

At IOP, the condensed matter theory group is actively involved in cutting edge research in the following branches of Condensed Matter Physics (CMP).

Quantum Condensed Matter Physics

In this field, we are actively involved in exploring topological aspects, strong correlation effects, various magnetic order and quantum transport properties of several quantum materials.

In particular, we have focused on Floquet generation of higher-order topological systems via various driving protocols starting from either first order topological insulator or Dirac semimetal, nature of metal-insulator transition and band-topology in a periodically driven interacting triangular lattice, intriguing phase diagram of Kane-Mele model superimposed with Haldane model and characterizing the new phases with spin Chern number, investigation of Heisenberg model on a Fisher lattice and finding out the new magnetic phases, spin-wave spectrum etc.

Biological and Soft Matter Physics

Current activity in this field is mainly focused around developing physical understanding of different biological phenomena and active matter.

Specifically, we have shown a remarkable mapping of the trajectories of active Brownian particles (ABPs) to equilibrium semiflexible polymers and developed the physical understanding of crossover from Gaussian to non- Gaussian distribution of position for ABPs with increasing trap stiffness. Furthermore, in biological systems, our recent focus has been on understanding properties of cytoskeletal complex involving motor proteins and semiflexible filaments, exploring the coupled dynamics of the shape fluctuations of a spherical membrane associated with diffusive membrane-bound activator proteins, and actomyosin cytoskeleton.

(G. Tripathy, S. Mandal, A. Saha, D. Chaudhuri)

1. (a) "Floquet generation of Higher Order Topological Systems hosting anomalous modes"

Non-equilibrium aspects of topological phases have attracted a great deal of attention in the community as the driven topological systems exhibit non-trivial properties which are absent in the corresponding static phase. In this direction, we have further proposed a simple fermionic model based on a three-dimensional topological insulator promised with *s*-wave superconductor to realize Majorana hinge modes (MHMs) followed by Majorana corner modes (MCMs) under the application of appropriate Wilson-Dirac perturbations. We interestingly find that the second-order topological superconductor, hosting MHMs, appears above a threshold value of the first type perturbation while the third-order topological superconducting phase, supporting MCMs, immediately arises incorporating infinitesimal perturbation of the second kind. Thus, a hierarchy of higher order topological superconductor (HOTSC) phases can be realized in a single three-dimensional model. We also analytically understand these above-mentioned numerical findings by resorting to the low-energy effective model. We further characterize these topological phases with a distinct structure of the Wannier spectra. From the practical point of view, we manifest quantized transport signatures of these higher-order modes. Finally, we construct Floquet engineering to generate the hierarchy of HOTSC phases by kicking the same perturbations as considered in their static counterpart.

In our earlier works, we have extensively investigated the Floquet second-order topological insulator (FSOTI) phase in two dimensions hosting mainly the zero quasi-energy modes. In our recent work, we propose two driving schemes (step drive and the mass kick protocols) to systematically engineer the hierarchy of the Floquet first-order topological insulator, the FSOTI, and the Floquet third-order topological insulator in three dimensions. Our driving protocols allow these Floquet phases to showcase regular 0, anomalous p, and hybrid 0-p-modes in a unified phase diagram, obtained for both two and three-dimensional (2D and 3D) systems, while starting from the lower-order topological or non-topological phases. These eventually enable us to understand the Floquet phase diagrams analytically and the Floquet higher-order modes numerically based on finite-size systems. The number of 0 and p modes can be tuned irrespective of the frequency in the step drive scheme, while we observe frequency-driven topological phase transitions for the mass kick protocol. We topologically characterize some of these higher-order Floquet phases (harbouring either 0 or anomalous p mode) by a suitable topological invariant in 2D and 3D cases.

(b) "Emergence of Non-Hermitian physics in Dirac semimetal-dirty Superconductor heterojunction"

In this direction, we theoretically investigate the emergence of non-Hermitian physics at the heterojunction of a type-II Dirac semi-metal (DSM) and a dirty superconductor (DSC). The non-hermiticity is introduced in the DSM through the self-energy term incorporated via the dirtiness of the superconducting material. This causes the spectra of the effective Hamiltonian to become complex, which gives rise to the appearance of the exceptional points (EPs). In the

spectral function analysis, apart from the EPs, a Fermi-arc like structure also emerges, which connects the two degeneracies (EPs). The results discussed here are distinctive and possibly can be realized in spectroscopy measurements.

(A. Saha)

2. (a) With Dr. Sanjay Gupta (Assistant Prof. Jharkhand C. U) I have investigated the effect of interction and disorder in Hopfstadter spectra in square and honeycomb lattice. This work has been published recently in JPCM. Our work shows that interction can succesfully nullify the effect of disorder in destroying the Hopfstadter spectrum and revive the spectram to some extent. The entanglement property has also been investigated in detail. It is observed that for Honeycomb lattice the area law is well maintained but not in square lattice.

(b) With my student Sudarshan Saha and collaborator Tanay Nag, we have investeged the topological phases of Haldane-Kane-Mele model. We have found all the possible eigth quantum hall phases in a single tight binding model. This work has been published in PRB. We have extended the scope of our work to investigate higher order topological phases. The work has been submitted in arXive recently. This work will be submitted to PRB soon.

(c) With my student Abhisek Bag, we have found that the beam splitter current in Iron-pnictide superconductor shows beutiful interference pattern due to the entanglement of hole and electron pocket. This work will be submitted to PRB soon.

(d) With my previous student Atanu Maity and Dr. Yasir Iqbal we have classified the projective symmetry group phases in decorated square lattice. This work has been included in his thesis and will submitted soon.

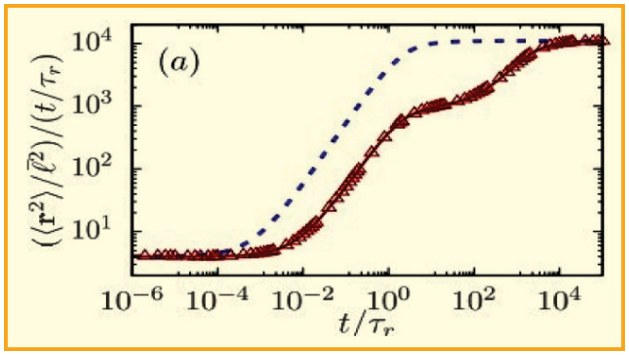
(e) With my student Moonsun Parvez we are investigating the the zero temperature and finite temperature properties of Kitaev-Heisenberg model. We have employed Jordan-Wigner transformations and exact diagonalization for this. Infact we have found an exact analytical solutions of fermionization which takes care of boundary condition exactly.

(S. Mandal)

3. The main focus of our group has been to understand properties of active matter, starting from the dynamics of single constituent active element to the novel many-body effects that emerge from the interaction between active elements. Active systems are driven out of equilibrium consuming and dissipating energy in the smallest length scale to produce self-propulsion or active stress. They break detailed balance and the equilibrium fluctuation dissipation relation. The study of active matter draws its main motivation from the non-equilibrium properties of biological systems, e.g., motile cells, bacteria, birds and animals. They often show spectacular collective properties: birds form flock while flying, bacteria or ants cluster together and show remarkable collective motion. Artificial active systems are created in laboratory using Janus colloids, several kinds of phoretic

motion like thermo-phoresis or diffusio-phoresis, such that individual elements generate self-propulsion. Despite tremendous progress in the knowledge of collective motion, surprisingly, stochastic dynamics of individual active elements remains to be fully understood.

One of our main contribution during the last one year was to develop quantitative understanding of the stochastic dynamics of self-propelled active Brownian particles (ABP). In the previous year, we developed an exact analytic method to calculate dynamical moments of ABPs that move with constant active speed. During last year, in two publications [*J. Stat. Mech.* 2022, 013201, *Phys. Rev. E* 105, 054148 (2022)], we have extended the method to calculate all possible dynamical moments of ABPs, incorporating



fluctuations in active speed, in arbitrary d-dimensions. This way we have extended the scope of our theory to the biologically relevant active particles, e.g., bacteria that does not always move with constant active speed. Instead, their active speed shows large stochastic variations, which may arise due to internal chemical processes leading to physical motion. We incorporated such mechanisms to derive several exact results including the mean-squared displacement (MSD), its dynamical crossovers, the effective diffusivity. Remarkably, the presence of speed fluctuations increases the effective diffusion constant increasing the span over which active elements can spread. This ability is useful for bacteria in search of food. Our analytic expression for MSD while interpreted in two-dimensions, shows exact agreement with numerical simulations. The figure above shows comparison of MSD data obtained from simulations (points) with our theory (line). For comparison, we also plot the inexact estimate from earlier publications (dashed blue line).

In a separate set of studies we focussed on biologically relevant filament-motor-protein system. We have shown how motor protein drive can lead to stable limit cycle oscillations observed in mitotic spindles [*Soft Materials* 19, 323 (2021)]. In *Soft Matter* 17, 10614 (2021) we have shown how coupling between elastic properties of a spherical membrane and membranebound proteins moving on this curved space, in the presence of actomyosin drive lead to membrane deformation and several dynamical phases in the protein concentration profile. This includes, pattern formation, localized pulsation, and running pulsation between two poles. Finally, in as yet unpublished arXiv : 2202.00366 we studied an active walker model to develop understanding of ant motion guided by the chemical trail that it produces.

(D. Chaudhuri)

PUBLICATIONS

3.1. Papers Published in Refereed Journals

1. **MoS2/SnO2 heterojunction-based self-powered photodetector**

   P Augustine, KL Kumawat, DK Singh, SB Krupanidhi, KK Nanda,, Applied Physics Letters 120, 181106 (2022)

2. **FeCoNiMnCr High Entropy Alloy Nanoparticles Grafted NCNTs with Promising Performance in Ohmic Polarization Region of Fuel Cell ACS Applied Materials & Interfaces**

   R Nandan, G Raj, KK Nanda, ACS Appl. Mater. Interfaces 2022, 14, 16108"16116 (2022)

3. **Self-assembled TMD nanoparticles on N-doped carbon nanostructures for oxygen reduction reaction and electrochemical oxygen sensing thereof**

   OY Bisen, S Atif, M Ambresh, KK Nanda, ACS Applied Materials & Interfaces 2022, 14, 5134"5148 (2022)

4. **Initial fluctuations and power spectrum of flow anisotropies in relativistic heavy-ion collsions**

   Shreyansh S. Dave, Saumia P.S. and Ajit M. Srivastava. Invited review article, Eur. Phys. J. Spec. Top. 230, 673 (2021)

5. **Modulation of pulse profile as a signal for phase transitions in a pulsar core**

   Partha Bagchi, Biswanath Layek, Anjishnu Sarkar, Ajit M. Srivastava, Mon.Not.Roy.Astron.Soc. 513, 2794 (2022)

6. **The role of amine in the sequestration of As (III) on functionalized indium tin oxide**

   Prescott E. Evans, Andrew J. Yost, Kayleigh A. McElveen, Qin-Yin Shi, Thilini K. Ekanayaka, Ashis K. Manna, Vicki Schlegel, Peter A. Dowben, Rebecca Y. Lai, Shikha Varma, Applied Surface Science 538, 147652 (2021)

7. **Tuning Photo-response and Electronic Behavior of Graphene Quantum Dots Synthesized via Ion Irradiation**

   Ashis Manna, Simeon J. Gilbert, Shalik R. Joshi, Takashi Komesu, Peter A. Dowben, Shikha Varma, Physica-B: Physics of Condensed Matter 613, 412978 (2021)

8. ***Oxygen vacancy assisted condensation of DNA molecule observed on ZnO thin film,*** C. Pal, S. Varma, S. Majumder, Biophysical Chemistry, 227 106659 (2021)

9. **Structural and Optical Properties of multilayered un-doped and cobalt doped TiO_2 films**

   Anupama Chanda, Shalik. R. Joshi, V. R. Akshay, Shikha Varma, Jai Singh, M. Vasundhara and Prashant Shukla. Applied Surface Science 536, 14783 (2021)

10. **Microstructural and bandgap investigations of wurtzite-phase ZnMgO nano-powders synthesized by ball-milling**

    Gaurav Gupta, Shikha Varma, R. Nagarajan, Shyama Rath, Physica B: Physics of Condensed Matter, 604, 412735 (2021)

11. **Di-vector boson production in association with a Higgs boson at hadron colliders**

    Pankaj Agrawal, Debashis Saha, and Ambresh Shivaji, Phys Rev D 103, 116020 (2021)

12. **WWH production through bottom quarks fusion at hadron colliders**

    Pankaj Agrawal and Biswajit Das, Phys Letts B 820, 136461 (2021)

13. **Rotating neutron stars with quark cores**

    I. A. Rathar, U. Rahman, M. Imran, H. C. Das, A. A. Usmani and S. K. Patra, Phys. Rev. C 103, 122315 (2021)

14. **Thermal impacts on the properties of nuclear matter and young neutron star,**

    A.Kumar, H. C. Das, M. Bhuyan and S. K. Patra, Nucl. Phys. A 1015, 122315 (2021)

15. **Heavy magnetic neutron stars**

    I. A. Rather, U. Rahaman, V. Dexheimer, A. A. Usmani and S. K. Patra, Astrohys. J. 917, 46 (2021)

16. **Effects of dark matter on the inspiral properties of the binary neutron star**

    H. C. Das, A. Kumar and S. K. Patra, Monthly Notices of the Royal Astronomical Society, 507 4053 (2021)

17. **Comments on the work entitled: Detail study of application of the relativistic mean field effective NN forces for heavy ion fusion within a dynamical model**

    M. Bhuyan, Raj Kumar and S. K. Patra, J. Phys. G48 088001 (2021)

18. **Hadron-Quark phase transition in the context of GW190814**,

    I. A. Rather, A. A. Usmani and S. K. Patra, J.Phys. G48 085201 (2021)

19. **Role of microscopic temperature-dependent binding energies in the decay of ^{32}Si formed in ^{20}O+^{12}C reaction**,

    Manpreet Kaur, B. B. Singh and S. K. Patra, Phys. Rev. C103 054608 (2021)

20. **Thermal effects in hot and dilute homogeneous asymmetric nuclear matter**,

    Vishal Parmer, Manoj K. Sharma and S. K. Patra, Phys. Rev. C103 055817 (2021)

21. **The kinks in charge radii across N=82 and 126 revisited**

    M. Bhuyan, B. Maheshwari, H. A. Kassim, N. Yusof, S. K. Patra, B. V. Carlson and P. D. Stevenson, J. Phys G48 075105 (2021)

22. **Systematic study for the surface properties for neutron stars**

    Ankit Kumar, H C Das, J. A. Pattnaik and S. K. Patra, Phys. Rev. C105, 005800 (2022)

23. **Crustal properties of the neutron star within effective relativistic mean-field model**,

    V Parmar, H C Das, A Kumar, M K Sharma, S. K. Patra, Phys. Rev. D105, 043017 (2022)

24. **Investigation of octupole deformed fragments decaying from even-even isotopes of $^{222-230}$Th***

    Shivani Jain, Raj Kumar, {\bf S K Patra} and Manoj K Sharma, Phys.Rev. C105 034605 (2022)

25. **Properties of hot finite nuclei and associated correlations with infinite nuclear matter**

    Vishal Parmar, Manoj K. Sharma, and S. K. Patra, Phys. Rev. C105 024316 (2022)

26. **Dark matter effects on the compact star properties**

    H C Das, Ankit Kumar, Bharat Kumar and S. K. Patra, Galaxies 10 14 (2022)

27. **Appearance of a peak in symmetry energy at N= 126 for the Pb isotopic chain within the relativistic energy density functional**

    Jeet Amrit Pattnaik, T M Joshua, Ankit Kumar, M Bhuyan and S. K. Patra, Phys. Rev. C105 014318 (2022)

28. **Surface properties for Ne, Na, Mg, Al and Si isotopes in the coherent density fluctuation model using the relativistic mean field densities**,

    J. A. Pattnaik, R. N.Panda, M. Bhuyan and S. K. Patra, Canadian J. Phys. 100 102 (2022)

29. **Impacts of dark matter on the f-mode oscillation of hyperon star**

    H. C. Das, Ankit Kumar, S. K. Biswal and S. K. Patra, Phys. Rev. D104 123006 (2021)

30. **Effect of Oriented Nuclei on the Competing Modes of á and One-Proton, Radioactivities in the Vicinity of Z= 82 Shell Closure**

    Sarbjeet Kaur, BirBikram Singh, S. K. Patra, Journal of Nuclear Physics, Material Sciences, Radiation and Applications, 9 31 (2021)

31. **Decay analysis of ^{24,25}Mg compound nuclei**

    Sarbjeet Kaur, Rupinder Kaur, BirBikram Singh and S. K. Patra, Nucl. Phys. A1018 122361 (2022)

32. **Isotopic shift and search of magic number in the super heavy region**

    Jeet Amrit Pattnaik, R. N. Panda, M. Bhuyan and S. K. Patra, Physica Scripta 96 125319 (2021)

33. **Understanding temporal evolution of microstructures on metal-assisted chemically etched Ge surface and its applications**

    Alapan Dutta, Ranveer Singh, Safiul Alam Mollick, Paramita Maiti and Tapobrata Som, Solar Energy 221, 185 (2021)

34. **Strongly antireflective nano-textured Ge surface by ion-beam induced self-organization**

    D. P. Datta and Tapobrata Som, Solar Energy 223, 375 (2021)

35. **White light modulated forming-free multilevel resistive switching in ZnO:Cu films**

    Mahesh Saini, Ranveer Singh, Anirban Mitra, and Tapobrata Som, Applied Surface Science 53, 150271 (2021)

36. **Ion Beam-Mediated Defect Engineering in TiO_x Thin Films for Controlled Resistive Switching Property and Application**

Dilruba Hasina, Mohit Kumar, Ranveer Singh, Safiul Alam Mollick, Anirban Mitra, S. K. Srivastava, Minh Luong, and Tapobrata Som, ACS Applied Electronic Materials 3, 3804 (2021)

37. **Controlled creation and annihilation of isolated robust emergent magnetic monopole like charged vertices in square artificial spin ice**

Neeti Keswani, R. J. C. Lopes, Y. Nakajima, Ranveer Singh, N. Chauhan, Tapobrata Som, D. Sakthi Kumar, Afranio R. Pereira, Pintu Das, Scientific Reports 11, 1 (2021)

38. **Morphological, optical, catalytic and photocatalytic properties of RF magnetron sput tered Au-Cu_2O-CuO nanocomposite thin films**

K. Sahu, A. Bisht, A. Dutta, Tapobrata Som, S. Mohapatra, Surfaces and Interfaces 26, 101436 (2021)

39. **Carrier selective MoOx/Si heterojunctions: Role of thickness**

Ranveer Singh, R. Sivakumar, S.K. Srivastava, and Tapobrata Som, Applied Surface Science 564, 150306 (2021)

40. **Structural and electrical transport properties of Ge implanted CoSb3 thin films and their conduction mechanisms**

Anha Masarrat, Anuradha Bhogra, Ramcharan Meena, M Sinduja, Dilruba Hasina, S Amirthapandian, Devarani Devi, Tapobrata Som, A Niazi, Asokan Kandasami, Journal of Materials Science: Materials in Electronics 27, 32701 (2021)

41. **Understanding the role of structural distortions on the transport properties of Ar ion irradiated $SrTiO_3$ thin films: X-ray absorption investigation**

Anuradha Bhogra, Anha Masarrat, Dilruba Hasina, Vishnu Kumar, Ramcharan Meena, Ashish Kumar, Tapobrata Som, Chung-Li Dong, Chi-Liang Chen, Asokan Kandasami, Journal of Applied Physics 130, 175102 (2022)

42. **Microstructural, surface morphological, and magnetic properties of oblique angle deposited Co thin films on ion-beam fabricated self-organized Si substrates**

Shiv Poojan Patel, Tanmoy Basu, Mohit Kumar, Pramita Mishra, Tapobrata Som, Materials Letters 308, 131099 (2022)

43. **Substrate roughness and crystal orientation-controlled growth of ultra-thin BN films de posited on Cu foils**

Nilanjan Basu, Alapan Dutta, Ranveer Singh, M Bayazeed, Avnish Singh Parmar, Tapobrata Som, Jayeeta Lahiri, Applied Physics A 128, 1 (2022)

44. **Measurement of ion backflow fraction in GEM detectors**

A. Tripathy, P. K. Sahu, S. Swain and S. Sahu, Nuclear Inst. and Methods in Physics Research, A 1013 165596 (2021)

45. **Thermal properties of hot and dense medium in interacting hadron resonance gas model**

Sarita Sahoo, D.K.Mishra and P.K.Sahu, Nuclear Physics A 1018 122362 (2022)

46. **Remote data acquisition with wireless communication for a quad-GEM detector;**

R. Bhattacharyya, S. Sahu and P. K. Sahu, Journal *of Instrumentation*, 17, T02001 (2022)

47. **Probing the Role of Local Structure in Driving the Stability of Halide Perovskites $CH_3NH_3PbX_3$**

P Nandi, S Mahana, E Welter, D Topwal, The Journal of Physical Chemistry C 125 (44), 24655-24662 (2021)

48. **Study on CH3NH3PbI3 Based Perovskite Solar Cell: An Approach to Antisolvent Treatment under Ambient Condition**

P Nandi, C Giri, U Bansode, D Topwal, Recent Trends in Chemical and Material Sciences Vol. 3, 24-30 (2021)

49. **Gd induced modifications in the magnetocaloric properties of dysprosium manganites**

A Prusty, S Mahana, A Gloskovskii, D Topwal, U Manju, Journal of Alloys and Compounds 883, 160862 (2021)

50. **Observation of room-temperature ferroelectricity in spark-plasma sintered**

S Mishra, K Rudrapal, A Rahaman, P Pal, A Sagdeo, R Mishra, D Topwal, Ayan Roy Chaudhuri, Venimadhav Adyam, Debraj Choudhury, Physical Review B 104 (18), L180101(2021)

51. **Prospects in Engineering Congested Molecular Diffusion at the Stabilizer Layer of Metal Nanocrystals for Ultrahigh Catalytic Activity**

L Sahoo, S Mondal, R Garg, U Manju, D Topwal, UK Gautam, The Journal of Physical Chemistry C 125 (18), 9827-9838 (2021)

52. **A close look on 2-3 mixing angle with DUNE in light of current neutrino oscillation data**

Sanjib Kumar Agarwalla, Ritam Kundu, Suprabh Prakash, Masoom Sing, Journal of High Energy Physics 03 206 (2022)

53. **Probing Lorentz Invariance Violation with Atmospheric Neutrinos at INOICAL**

Sadashiv Sahoo, Anil Kumar, Sanjib Kumar Agarwalla, Journal of High Energy Physics 03 050 (2022)

54. **Evolution of Neutrino Mass-Mixing Parameters in Matter with Non-Standard Interactions**

Sanjib Kumar Agarwalla, Sudipta Das, Mehedi Masud, Pragyanprasu Swain, Journal of High Energy Physics 11 094(2021)

55. **Validating the Earth's Core using Atmospheric Neutrinos with ICAL at INO**

Anil Kumar, Sanjib Kumar Agarwalla, Journal of High Energy Physics 08 139 (2021)

56. **A New Approach to Probe Non-Standard Interactions in Atmospheric Neutrino Experiments**

Anil Kumar, Amina Khatun, Sanjib Kumar Agarwalla, Amol Dighe, Journal of High Energy Physics 04 159 (2021)

57. **Eightfold quantum Hall phases in a time reversal symmetry broken tight binding model**

Sudarshan Saha, Tanay Nag, and Saptarshi, Mandal, Phys. Rev. B, 103, 235154 (2021)

58. **Interacting fermions in two dimension in simultaneous presence of disorder and magnetic field**

Saptarshi Mandal, Sanjay Gupta, 2022 J. Phys.: Condens. Matter 34 215602 (2022)

59. **Systematic generation of the cascade of anomalous dynamical first and higher-order modes in Floquet topological insulators**

Arnob Kumar Ghosh, Tanay Nag and Arijit Saha, Phys. Rev. B 105, 115418 (2022)

60. **Hierarchy of higher-order topological superconductor in three dimensions**

Arnob Kumar Ghosh, Tanay Nag and Arijit Saha, Phys. Rev. B 104, 134508 (2021)

61. **Emergence of exceptional points and their spectroscopic signature in Dirac semimetal- dirty Superconductor heterojunction**

Sayan Jana, Debashree Chowdhury and Arijit Saha, Phys. Rev. B 103, 235438 (2021)

62. **Electric Field Modulated Charge Transfer in Geometrically Tailored MoX_2=WX_2 (X=S, Se) Heterostructures**

S. Sahoo, M. C. Sahu, S. K. Mallik, N. Kapila Sharma, A. K. Jena, S. Gupta, R. Ahuja and S. P. Sahoo, Journal of Physical Chemistry C 125, 40, 161336 (2021)

63. **Strain-mediated Ferromagnetism and Low-field Magnetic Reversal in Co-doped mono layer WS_2**

A. K. Jena, S. K. Mallik, S. Sahoo, M. C. Sahu, A. Sahoo, N. K. Sharma, J. Mohanty, S. Gupta, R. Ahuja and S. P. Sahoo, Scientific Reports 12, 2593 (2022)

64. **Multilevel Resistive Switching in Graphene Oxide-Multiferroic Thin-film based Hybrid RRAM Device by Interfacial Oxygen Vacancy Engineering**

A. K. Jena, M. C. Sahu, S. Sahoo, S. K. Malik, G. K. Pradhan, J. Mohanty and S. P. Sahoo. Applied Physics A 128, 213 (2022)

65. **Electronic Bandstructure Modulation of MoX_2=ZnO (X: S, Se) Heterostructure by Applying External Electric Field for Novel-Electronic Devices.**

N. K. Sharma, S. Sahoo, M. C. Sahu, S. K. Mallik, A. K. Jena, S. Gupta, H. Sharma, R. Ahuja and S. P. Sahoo, Surfaces and Interfaces 29, 101817 (2022)

66. **Active Brownian motion with speed fluctuations in arbitrary dimensions: exact calculation of moments and dynamical crossovers**

A. Shee, Debasish Chaudhuri, J. Stat. Mech. Theory Exp.2022, 013201 (2022)

67. **Self-propulsion with speed and orientation fluctuation: exact computation of moments and dynamical bistabilities in displacement**

A. Shee, Debasish Chaudhuri, Phys. Rev. E 105, 054148 (2022)

68. **Pattern formation, pulsation and traveling wave on active spherical membranes**

S Ghosh, S Gutti, Debasish Chaudhuri, Soft Matter 17, 10614 (2021)

69. **Filament-motor protein system under loading: instability and limit cycle oscillations**

A Shee, S Ghosh, Debasish Chaudhuri, Soft Materials 19, 323 (2021)

70. **Evidence for Spin-Orbit and e-e Coulomb Interaction from Magnetotransport Study on $CaCu_3Ru_4O_{12}$ thin films**

Subhadip Jana, T. Senapati, and D. Samal, Phys. Rev. B 103, 245109 (2021)

71. **Tailoring magnetism in spinel vanadate CoV_2O_4 epitaxial thin-films**

B. C. Behera, G. Sabat, Shwetha G. Bhat, S. N. Sarangi, B. R. Sekhar, D. Samal, J. Phys.: Condens. Matter 33, 365801 (2021)

72. **Manifestation of Dissimilar Types of Magnetism in Iron and Chromium Substituted Mn_2SnS_4**

Tuhin Subhra Dash, Subham Naik, Sheetal, S. N. Sarangi, D Samal, C S Yadav, S. D. Kaushik, and Saroj L. Samal, Dalton Trans., 50, 15711-15720 (2021)

73. **Subsubleading soft graviton symmetry and MHV graviton scattering amplitudes**

S.Banerjee, S.Ghosh and S.S.Samal, JHEP {08}, 067 (2021)

74. **Relativistic freeze-in with scalar dark matter in a gauged B-L model and electroweak symmetry breaking**

Priyotosh Bandyopadhyay, Manimala Mitra, Abhishek Roy, JHEP 05 150 (2021)

75. **Right handed neutrinos, TeV scale BSM neutral Higgs boson, and FIMP dark matter in an EFT framework**

Genevieve ‘Belanger, ´Sarif Khan, Rojalin Padhan, Manimala Mitra, Sujay Shil, Phys. Rev. D 104 5, 055047 (2021)

76. **Zooming in on eV-MeV scale sterile neutrinos in light of neutrinoless double beta decay**

Tapoja Jha, Sarif Khan, Manimala Mitra, Ayon Patra, Phys. Rev.D 105 (2022)

77. **Exploring the new physics phases in 3+1 scenario in neutrino oscillation experiments**

Nishat Fiza, Mehedi Masud, Manimala Mitra, JHEP 09 162 (2021)

78. **Methodology to determine the spin-parity of muon-philic X boson in** $J/\Psi \rightarrow \mu^+\mu^- + X$ **decay**

Manimala Mitra, Dibyakrupa Sahoo, Phys. Rev. D 104 1, 015002.

79. **Type-III see-saw: Search for triplet fermions in final states with multiple leptons and fat-jets at 13 TeV LHC**

Saiyad Ashanujjaman, Kirtiman Ghosh, Phys.Lett.B 825, 136889 (2022)

80. **Revisiting type-II see-saw: present limits and future prospects at LHC**

Saiyad Ashanujjaman, Kirtiman Ghosh, JHEP 03 195 (2022)

81. **Type-III see-saw: Phenomenological implications of the information lost in decoupling from high-energy to low-energy**

Saiyad Ashanujjaman, Kirtiman Ghosh, Phys.Lett.B 819, 136403 (2021)

82. **Magnetic Phase Transition and magneto-elastic coupling in** $Fe_{1+x}Cr_{2-x}Se_4$ **(x= 0.0- 0.50)**

V. Singh, S.N. Sarangi, D. Samal, R. Nath, Materials Research Bulletin, 111941 (2022)

83. **Dependence of Cu Doping on Stucture, Morphology, Magnetic and Biomedical Proper ties of ZnO Nanostructures**

S.N. Sarangi, S. Acharya, S.K. Biswal, K.K. Nanda, Materials Today Communications, 103803 (2022)

84. **Band gap engineering in ZnO Nanostructures / Microstructures**

S. Acharya, S.N. Sarangi, S.K. Biswal, Indian Journal of Natural Sciences 13 (71), 41541-41549 (2022)

85. **Room temperature multiferroicity with enhanced ferroelectric and ferromagnetic properties in** $Ba_{0.75}Pb_{0.25}Ti_{1-x}Fe_xO_3$

R. Amin, K. Samantaray, S. Ayaz, S.N. Sarangi, I. Bhaumik, S. Sen, Journal of Alloys and Compounds 897, 162734 (2022)

86. **Magnetic performance of Bi architecture á-Fe2O3/NiFe2O4 nanocomposite**

S. Jena, D.K. Mishra, S.N. Sarangi, P. Mallick, Journal of Superconductivity and Novel Magnetism 35 (3), 833-838 (2022)

87. **Facile synthesis of Super-paramagnetic Au@ á-Fe2O3 hybrid nanoparticle and it's as sembly on graphene substrate for visible light Photo-catalysis**

R.K Sahoo, A.K Manna, A. Das, A. Mitra, M. Mohapatra, S.N. Sarangi, P. Garg, U.Desh pande, S.Varma., Applied Surface Science 577, 151954 (2022)

88. **Facile two step synthesis of chemiresistive sensor based on ãFe$_2$O$_3$—activated carbon composites for room temperature alcohol vapour detection**

L. Jena, S.N. Sarangi, D. Soren, P.K. Deheri, P. Pattojoshi, Applied Physics A 128 (2), 1-11 (2022)

89. **Enhanced critical current density and flux pinning of anthracene doped magnesium diboride superconductor**

Ahmad, S.N. Sarangi, P.M. Sarun**,** Journal of Alloys and Compounds 884, 160999 (2021)

90. **Schottky junction devices by using bio-molecule DNA template-based one dimensional CdS-nanostructures**

S.N. Sarangi, B.C. Behera, N.K. Sahoo, S.K. Tripathy, Biosensors and Bioelectronics 190, 113402 (2021)

91. **Tailoring magnetism in spinel vanadate CoV2O4 epitaxial thin films**

B.C. Behera, G. Sabat, S.G. Bhat, S.N. Sarangi, B.R. Sekhar, D. Samal, Journal of Physics: Condensed Matter 33 (36), 365801 (2021)

92. **Dielectric, electrical and magnetic characteristics of BST modified BLFO lead free ceramic**

B. Mohanty, S. Bhattacharjee, S.N. Sarangi, N.C. Nayak, R.K. Parida, B. N. Parida, Journal of Alloys and Compounds 863, 158060 (2021)

93. **Nominal Effect of Mg Intercalation on the Superconducting Properties of 2H–NbSe$_2$**

S. Naik, S. Kalaiarasan, R.C. Nath, S.N. Sarangi, A.K. Sahu, D. Samal, H.S. Biswal, S.LSamal Inorganic Chemistry 60 (7), 4588-4598 (2021).

94. **Positive exchange bias and inverted hysteresis loop in Y$_3$Fe$_5$O$_{12}$/Gd$_3$Ga$_5$O$_{12}$**

R. Kumar, S.N. Sarangi, D. Samal, Z. Hossain, Physical Review B 103 (6), 064421 (2021)

95. **Manifestation of dissimilar types of magnetism in iron-and chromium-substituted Mn$_2$ SnS$_4$**

T.S. Dash, S. Naik, S.N. Sarangi, D. Samal, C.S. Yadav, S.D. Kaushik, Dalton Transactions 50 (43), 15711-15720 (2021)

96. **Emergence of carbon nanoscrolls from single walled carbon nanotubes: an oxidative route**

Sonia Saini, Reshmi S., Girish M. Gouda and Kuntala Bhattacharjee; Physical Chemistry Chemical Physics (PCCP) 23, 27437–27448, 2021 DOI: 10.1039/d1cp03945h (2021)

97. **Intermediate Cu-O-Si phase in the Cu-SiO2/Si(111) system: growth, elemental and electrical studies**

S. Reshmi, Manu Mohan, Sonia Saini, Anupam Roy, Kuntala Bhattacharjee; *ACS Omega* 6, 23826- 23836, 2021 DOI: 10.1021/acsomega.1c02646

98. **Elasticity of a DNA chain dotted with bubbles under force**

D. Majumdar, physical review E 103, 052412 (2021)

99. **Critical behavior of magnetic polymers in two and three dimensions**

D. P. Foster and D. Majumdar, physical review E 104, 024122 (2021)

- **ALICE Collaboration Publication: S. Acharya…P. K. Sahu...et al.**

  IOP is a part of ALICE collaboration (Prof. P.K. Sahu) and total number of publications for the year 2021-2022 are 42.

- **CMS Collaboration Publication: A. M. Sirunyan ... A. Nayak et al.**

  IOP is a part of c collaboration (Dr. Aruna K. Nayak) and total number of publications for the year 2021-2022 are 76.

3.2 Conference proceedings :

1. **Gain uniformity of a quad-GEM detector**

   Rupamoy Bhattacharyya, Pradip Kumar Sahu, Sanjib Kumar Sahu, Ramaprasad Adak; International Journal of Modern Physics E and Springer Proceedings in Physics, (2021)

2. **Gain uniformity of a quad-GEM detector at different gas flowrate**

   Rupamoy Bhattacharyya, Pradip Kumar Sahu, Sanjib Kumar Sahu, Ramaprasad Adak; Springer Proceedings in Physics, (2021)

3. **Effect of Dark Matter In Compact Realistic Neutron Stars Matter**

   P. K. Sahu, D. K. Mishra and S. P. Behera Springer Proceedings in Physics, (2021)

4. **Exploring Earth's Matter Effect in High-Precision Long-Baseline Experiments**

   Masoom Singh, Sanjib Kumar Agarwalla, Contribution to the Conference EPS-HEP2021, e-Print arXiv:2110.11215 [hep-ph]

5. **Probing the Earth's Core using Atmospheric Neutrinos at INO**

   Anil Kumar, Sanjib Kumar Agarwalla, Contribution to the Conference EPS-HEP2021 e-Print arXiv:2110.08333 [hep-ph]

6. **Exploring the Violation of Lorentz Invariance using Atmospheric Neutrinos at INO-ICAL**

   Sadashiv Sahoo, Anil Kumar, Sanjib Kumar Agarwalla Contribution to the 17th International Conference on Topics in Astroparticle and Underground Physics (TAUP2021) J.Phys.Conf.Ser. 2156, 012238(2021)

7. **Structure assigned optical transitions from single walled carbon nanotube based high absorber composite thin film coatings**

   Sonia Saini, S Reshmi, Girish M Gouda, Kuntala Bhattacharjee; *IOP Conf. Ser.: Mater. Sci. Eng.* 1221 012042, (2022)

8. **In-situ STS studies and first principles calculations on bare and Sn adsorbed UHV exfoliated WS2 layers**

   Manu Mohan, Vipin Kumar Singh, Mihir Ranjan Sahoo, S Reshmi, Sudipta Roy Barman, Kuntala Bhattacharjee; IOP Conf. Ser.: Mater. Sci. Eng. 1221 012046, (2022)

9. **Silver adsorption on monolayer MOS2 and WS2: A first principles study**

   S Reshmi, Mihir Ranjan Sahoo, Kuntala Bhattacharjee; Proceedings of the 65th DAE Solid state physics symposium, Vol 55 (2021), Pg No: 564, ISBN:81-8372-085-4

10. **In-situ STS studies and first principles calculations on the mechanically exfoliated WS2 layers**

    Manu Mohan, Vipin Kumar Singh, Mihir Ranjan Sahoo, S Reshmi, Sudipta Roy Barman, Kuntala Bhattacharjee; Proceedings of the 65th DAE Solid state physics symposium, Vol 55 (2021), Pg No: 578, ISBN:81-8372-085-4

11. **Corelation between and absorption features and optical transitions from SWCNT based thinfilm coating**

    Sonia Saini, S Reshmi, Girish M Gouda, Kuntala Bhattacharjee; Proceedings of the 65th DAE Solid state physics symposium, Vol 55 (2021), Pg No: 564, ISBN: 81-8372-085-4

3.3 Other Publications (by Library Staff)

- **Research on Fake News: An Empirical Analysis of Selected Library and Information Science Journals,**

  Sahoo, J., Sahu, S.C., and Mohanty, B**.**, *DESIDOC Journal of Library & Information Technology*, Vol. 41, No. 4, 455-462, DOI: 10.14429/djlit.41.4.17168 (2021)

- **Research Productivity and Citation Impact of Indian institutes of Science Education and Research,**

  Sahoo, J., Sahu, S.C., and Mohanty, B. *DESIDOC Journal of Library & Information Technology*, Vol. 41, No. 6, 455-462, DOI: 10.14429/djlit.41.6.17069 (2021)

3.4. (A) AWARDS / HONOURS AND RECOGNITIONS FACULTY

Prof. Shikha Varma

- Endowment Chair Professor, Dr. K. C. Patel Research & Development Center (KRADLE), CHARUSAT, Gujarat : Since 2021

Prof. T. Som

- Executive Body Member (Eastern India), Ion Beam Society of India (Continuing)

Prof. Sanjib K Agarwalla

1. The Prestigious Fulbright-Nehru Academic and Professional Excellence Fellowship (FNAPE) for the year 2021 - 2022

2. Appointed as an Honorary Fellow of the Physics Department, University of Wisconsin-Madison, Madison, USA
3. Associate Membership of the Abdus Salam International Centre for Theoretical Physics (ICTP) for Six Years (2022 to 2027)
4. Featured in the Coffee Table Book titled "75 Scientists under 50" as a part of the Golden Jubilee Celebrations of the Department of Science and Technology (DST), Govt. of India.

Prof. Shamik Banerjee

- Awarded DST Swarnajayanti Fellowship in the year 2021 in the Physical Science branch.

Dr. Manimala Mitra

- Received IPPP Diva Award, March 2022

3.4 (B) AWARDS / HONOURS AND RECOGNITIONS SCHOLARS

- Vinaykrishnan (student) was appointed as Level-3 Tau-Trigger group convener in CMS collaboration, for two years starting from September 2021.
- Ms. Rojalin Padhan (Ph.D. student) has received prestigious Fulbright-Nehru Doctoral Research Fellowship 2022-2023.

OTHER ACTIVITIES

4.1 Foundation Day

Institute of Physics, Bhubaneswar celebrated its 47th Foundation Day in hybrid mode (Online & Physical) on its premise on 4th September, 2021, adhering to the Government Guidelines. Eminent Professors in Physics across India delivered four Foundation Day Lectures on different domains of Physics. In the first session, Prof. Tarun Souradeep, Chair, Department of Physics, IISER, Pune, delivered a lecture on "New horizons with Gravitational waves". In the second technical session, Prof. Amit Roy, Ex-Director, Inter-University Accelerator Centre & Adjunct Professor, Manipal Centre for Natural Sciences, delivered a lecture on "Accelerators and Structure of Matter". In his deliberation, Prof. Roy discussed the possibilities of using accelerators in materials modification, Food preservation, energy production, and radioactive waste disposal management. In the third technical session, Prof. Pinaki Majumdar, Director, Harish-Chandra Research Institute (HRI), Prayagraj, delivered a lecture on "A classical approach to quantum many-body theory" followed by Prof. Gautam Bhattacharyya, Director, Saha Institute of Nuclear Physics (SINP), Kolkatta. Prof. Bhattacharyya delivered a talk on "A brief history of the Higgs boson". In the evening, Prof. Karuna Kar Nanda, Director, Institute of Physics, Bhubaneswar, graced the occasion in the presence of Prof. S. K. Patra, Chairman, FDCC-2021, along with Prof. T. Som, Member, FDCC-2021, at the Institute's Lecture Hall. The meeting ended with a formal vote of thanks by Shri. Rushi Kumar Rath, Registrar, Institute of Physics, Bhubaneswar. The whole-day long programme was coordinated by Dr. Basudev Mohanty, Convener along with the other members of the Foundation Day Celebration Committee (FDCC-2021) of the Institute.

4.2. Outreach Programme

National Science Day

As a part of the celebration of National Science Day 2022, IoP organized an "OPEN DAY" on 28th February at the premises of the Institute. The major activities included in this day-long programme were Live Demo Projects, Laboratory Visit, Poster Presentations, and Scientific Movie Display in the Institute's Auditorium. About 700 plus students, teachers from 33 institutes visited IOP and participated in the Scientific Programme. The prime objective of this celebration was to bring Science to the forefront, awaken the scientific spirit and temper of the people of our State. Each year National Science Day follows a particular theme, and this year the theme of the celebration was "*Integrated Approach in Science and Technology for Sustainable Future*". Many of the live demos were demonstrated on the said theme. The day-long programme was a grand success, and most of the participants requested IoP to conduct this type of event at regular intervals.

ଆଜି ଇନ୍‌ଷ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସରେ ଜାତୀୟ ବିଜ୍ଞାନ ଦିବସ

ଭୁବନେଶ୍ୱର,୨୭।୨(ବ୍ୟୁରୋ): ଇନ୍‌ଷ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସରେ ଆସନ୍ତାକାଲି ଜାତୀୟ ବିଜ୍ଞାନ ଦିବସ ପାଳନ କରାଯିବ। ନିରନ୍ତର ଭବିଷ୍ୟତ ପାଇଁ ବିଜ୍ଞାନ ଓ ପ୍ରଯୁକ୍ତିବିଦ୍ୟାର ଆବଶ୍ୟକତା ଶୀର୍ଷକକୁ ନେଇ ଏହି ଦିବସ ପାଳନ କରାଯିବ। ଏହି ଅବସରରେ ଆସନ୍ତାକାଲି ଅନୁଷ୍ଠାନରେ ବିଭିନ୍ନ ପରୀକ୍ଷାନିରୀକ୍ଷା ଉପରେ ଡେମୋ ଦେଖାଯିବ। ଲାଇଭ୍‌ଡେମୋ ପରିଦର୍ଶନ ଓ ସାଇଣ୍ଟିଫିକ୍ ପୋଷ୍ଟର ମଧ୍ୟ ପ୍ରଦର୍ଶନ ହେବ। ଛାତ୍ରଛାତ୍ରୀ, ଶିକ୍ଷକ, ଅଭିଭାବକ ଓ ସାଧାରଣ ଲୋକମାନେ ଅନୁଷ୍ଠାନକୁ ଆସି ପରିଦର୍ଶନ କରିବା ପାଇଁ ଶିକ୍ଷାନୁଷ୍ଠାନ ପକ୍ଷରୁ କୁହାଯାଇଛି।

Prof. A.M. Srivastava

1. Liquid Crystal demonstration on National Science Day- 2022

Experimental demonstration of formation of liquid crystal topological string defects during a phase transition was carried out for visiting students and general public during the Open House celebration of National Science Day on 28th Feb. 2022 at IOP. Correspondence of this phenomenon to formation of cosmic strings in the Universe and how liquid crystal expriments are used to test cosmic string theories was explained to the visitors.

2. Night sky watch program with telescopes :

We arrange Night sky watch programs regularly at the Institute for all the members of IOP and their families. The program is conducted with an 8" Schmidt-Cassegrain 2 meter focal length telescope, computer controlled with GPS system, and with a 4" refractor telescope, with manual controls, along with binoculars.

A night sky view session was arranged on 9th Nov. 2021 for IOP members and their families. Objects viewed: Moon craters, Saturn, Jupiter, Uranus.

3. Popular Science Talks/ Social Issues

Social Issues:

1. Online Talk on "Scientific Outlook" in the Inaugural Session for the Bigyan Chetana Mancha Website, Bhubaneswar, 18th July, 2021.
2. Participated as a panelist in the "Panel Discussion on Building barrier free access to research publications", organized by Bigyan Chetana Mancha, Bhubaneswar, 1st Sept. 2021.
3. Participated in the 1st One Day State Level Science Teachers' camp on "Questioning in Science", organized Online by Bigyan Chetana Mancha, Bhubaneswar. 19th Oct. 2021

Prof. Shikha Varma

Endowment Chair Lecture to students of Charotar University of Science and technology CHARUSAT, Changa, Gujarat (27 Sept. 2021). Four Lectures were given:

(a) From Surfaces to Nanotechnology to Nano Bio

(b) Fabricating Useful Surfaces and Nanostructures

(c) Investigating Surfaces and Nanostructure: Morphology and Composition

(d) Applications with Surfaces and Nanostructures: Sensors and Catalysis

Prof. Pradip Kumar Sahu

Outreach programme on "Atomic Energy Application to Society" at Khordha Village, Odisha on 29th November 2021.

4.3 AZADI KA AMRIT MAHOTSAV (AKAM) PROGRAM

As per the directive of the Department of Atomic Energy, Institute of Physics, Bhubaneswar is celebrating India's 75th year of Independence as ***'Azadi Ka Amrit Mahotsav'.*** Following activities have been carried out under this program during March 2022.

1. Kalinga TV program on Samanta Chandrasekhara

Kalinga TV presented a half hour program on Dec 12 on Samanta Chandrasekhara, the legendary 19th century Indian astronomer, which included interviews of Prof. L. Satpathy (retd. Professor, IOP) and Prof. A.M. Srivastava (Professor, IOP). Prof. Satpathy and Prof. Srivastava discussed great works of Samanta Chandrasekhar, the naked eye astronomer, his extremely precise measurements, and his exceptional experimental skills in making various instruments for astronomical measurements with everyday materials such as wooden sticks and bamboo. They emphasized the importance of bringing his works to limelight, and recognizing him as a role model as an exceptional experimental physicist.

YouTube link : https://www.youtube.com/watch?v=t1h_1tjQHSY

2. Popular Science talk for B.Sc. students at Banki college

A popular science talk on "The universe, elementary particles, and dark energy" was given by Prof. A.M. Srivastava on 15th Dec. for B.Sc. Students at the Physics Dept., Banki College, Banki, Odisha.

3. Hindi Workshop organized jointly by Institute of Physics, Bhubaneswar and Town Official Language Implementation Committee (Central), Bhubaneswar, Department of Official Language, Govt. of India.

Institute of Physics, Bhubaneswar organized the Hindi Workshop jointly with Town Official Language Implementation Committee (Central), Bhubaneswar on 15.12.2021 in the Institute. About 50 officials from different offices working under Govt. of India in Bhubaneswar participated in this workshop. Sri Roshan Pandey, Chief Manager (Hindi), NALCO and Sri Hariram Pansari, Consultant (Hindi), STPI, Bhubaneswar attended as Invited Speaker. Mr. Pandey deliberated on Hindi Grammar and Parliamentary Inspection Questionnaire and Sri Pansari deliberated about Qrtly. Report filling procedures and Rajbahsha Techniques.

(Inauguration function of the Workshop)

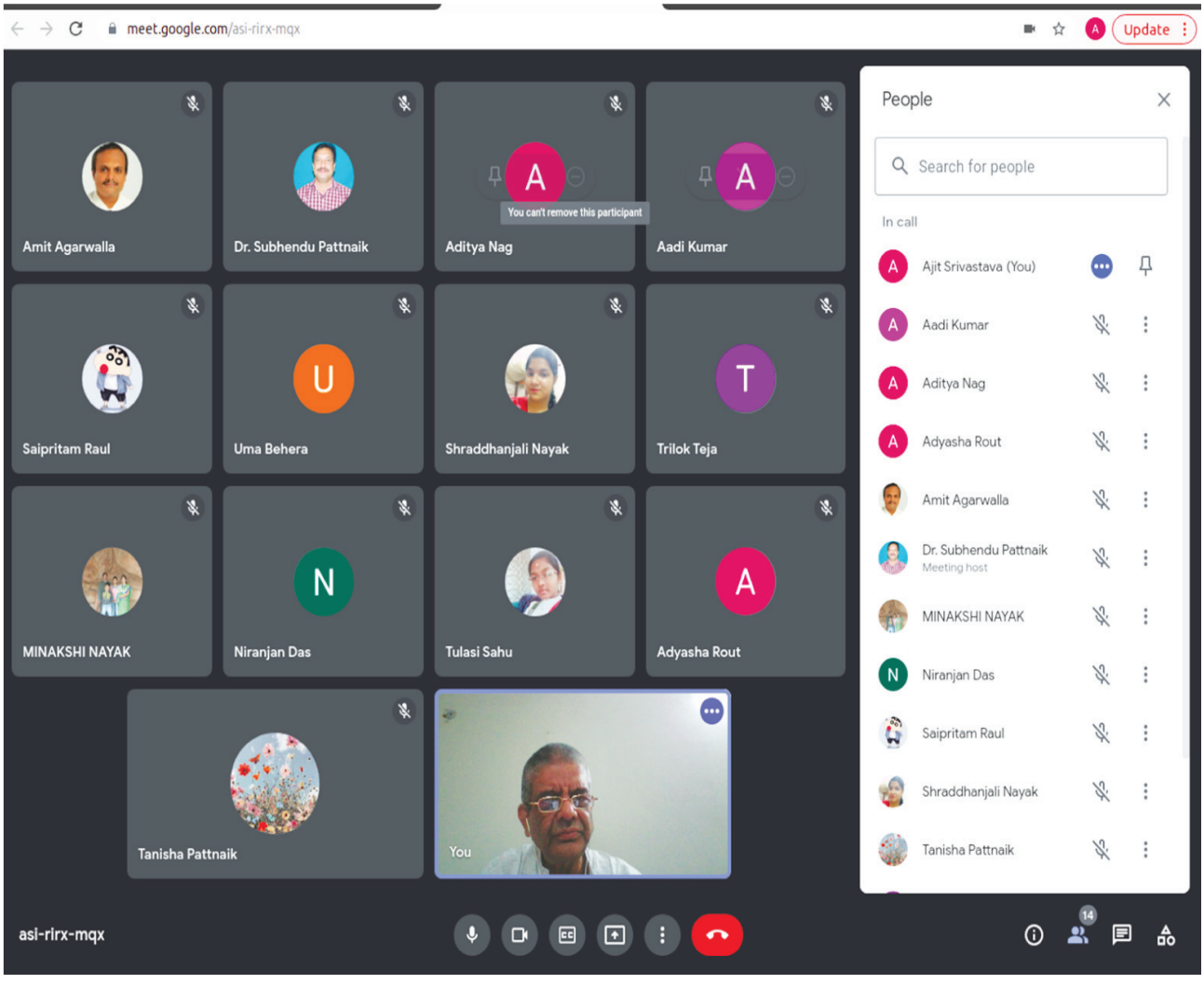
(Valedictory function of the Workshop)

(Participants during the workshop)

4. Scientists-School Students online interaction program: Fourth Session of Physics Open Discussion (POD) at IOP Bhubaneswar

The Fourth Session of the Monthly Physics Open Discussion (POD) online program at IOP Bhubaneswar was held on 18th Dec. 2021 during 5:30 pm – 7 pm. The program was attended by about 15 school students from all over Odisha from class VI to class XII on Zoom online platform. Questions ranging from basic physics concepts (Newton's laws of motion, light scattering by gases, quantum physics, energy quantization, sound waves), to frontier areas of physics (muon catalized fusion, time dilation, relativistic mas, from internet exposure of students) were discussed. Students asked questions in English, Hindi, and Odiya.

POD Online Session No. 4, Dec 18th, 2021



YouTube link for the session:https://www.youtube.com/watch?v=jKSVgddnUkg&t=888s

5. Popular Science talk at the State Level Science Seminar on "Exploring the Universe" held at Nimapara College, Odisha

A popular science talk on "Universe and elementary particles" was given by Prof. A.M. Srivastava on 20th Dec. at the State level Science seminar on "Exploring the Universe". The seminar was arranged at the Nimapara College, Nimapara, Odisha.

'ବ୍ରହ୍ମାଣ୍ଡର ଅନୁସନ୍ଧନ' ରାଜ୍ୟସ୍ତରୀୟ ପାଠଚକ୍ର

ନିମାପଡା, ୨୦/୧୨(ଶୁ.ମି.) : ସୋମବାର ପୂର୍ବାହ୍ନରେ ସ୍ଥାନୀୟ ସ୍ୱୟଂ ଶାସିତ ମହାବିଦ୍ୟାଳୟର ସମ୍ମିଳନୀ କକ୍ଷରେ ପଠାଣୀସାମନ୍ତ ପ୍ଲାନେଟୋରାୟମ ସହାୟତାରେ 'ବ୍ରହ୍ମାଣ୍ଡର ଅନୁସନ୍ଧନ' ଶୀର୍ଷକ ପାଠଚକ୍ର ଅଧକ୍ଷ ରମାକାନ୍ତ ଦାସଙ୍କ ଅଧକ୍ଷତାରେ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି। ଇଣ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସ, ଭୁବନେଶ୍ୱରର ପ୍ରଫେସର ଅଜିତ ମୋହନ ଶ୍ରୀବାସ୍ତବ ଓ ପଠାଣୀସାମନ୍ତ ପ୍ଲାନେଟୋରିୟମ୍‌ର ଡେପୁଟି ଡାଇରେକ୍ଟର ଡ. ସୁଭେନ୍ଦୁ ପଟ୍ଟନାୟକ ଏହି ଆଲୋଚନା ଚକ୍ରରେ ଭାଗ ନେଇ ବ୍ରହ୍ମାଣ୍ଡର ଉତ୍ପତି ଓ ଅନ୍ୟାନ୍ୟ ବହୁ ଗୁରୁତ୍ୱପୂର୍ଣ୍ଣ ଦିଗ ଉପରେ ସୁଚିନ୍ତିତ ମତାମତ ଦେଇଥିଲେ। ଏହା ବ୍ୟତୀତ ଏହି ପାଠଚକ୍ରରେ ଉପସ୍ଥିତ ଥିବା ଅନେକ ଛାତ୍ରଛାତ୍ରୀଙ୍କ ମନରେ ବ୍ରହ୍ମାଣ୍ଡ ସମ୍ପର୍କରେ ଉଙ୍କି ମାରୁଥିବା ଅନେକ ଅମିମାଂଶିତ ପ୍ରଶ୍ନର ଉତ୍ତର ଶ୍ରୀଯୁକ୍ତ ଶ୍ରୀବାସ୍ତବ ଓ ଶ୍ରୀ ପଟ୍ଟନାୟକ ଦେଇଥିଲେ। ମହାବିଦ୍ୟାଳୟ ପରିଚାଳନା କମିଟିର ସଭାପତି ପ୍ରାକ୍ତନ ଅଧ୍ୟାପକ ଜଗତପ୍ରସାଦ ସାବୁତ, ଡ. ବେଣୁଧର ସେନାପତି, ଅଧ୍ୟାପକ ଅମିତାଭ ଦାଶ ପ୍ରମୁଖ ଯୋଗଦେଇ ଛାତ୍ରଛାତ୍ରୀମାନେ ଏହି ପାଠଚକ୍ରରୁ ଅନେକ ଉପାଦେୟ କଥା ଶିକ୍ଷିବା ସହିତ ଭବିଷ୍ୟତରେ ଜଣେ ଜଣେ ଭଲ ବୈଜ୍ଞାନିକ ହୋଇପାରିବେ ବୋଲି ସେମାନେ କହିଥିଲେ। ମଞ୍ଚାସୀନ ସମସ୍ତ ଅତିଥି ଓ ମାନସ ରନ ସ୍ୱାଇଁଙ୍କୁ ସମ୍ବର୍ଦ୍ଧିତ କରାଯାଇଥିଲା। ଅଧ୍ୟାପିକା ପୁଷ୍ପିତା ରାଜଗୁରୁ, ଅଧ୍ୟାପକ ଡ. ରବୀନ୍ଦ୍ରନାଥ ପାତ୍ରୀ ଓ କୃଷ୍ଣଚନ୍ଦ୍ର ସାବୁତ୍ ପ୍ରମୁଖ ଏହି କାର୍ଯ୍ୟକ୍ରମକୁ ପରିଚାଳନା କରିଥିଲେ। ଏସ୍‌ପିଏସ୍ କଲେଜ ପୁରୀ, ବିଏସ୍. କଲେଜ, ପି.ଏନ୍. କଲେଜ, ଭିଏନ୍ କଲେଜ, ନିଆଳି କଲେଜ ଓ ଏନ୍.ଏସ୍ କଲେଜର ଅଧ୍ୟାପକ ଓ ଛାତ୍ରଛାତ୍ରୀମାନେ ମଧ୍ୟ ଏହି ପାଠଚକ୍ରରେ ଭାଗ ନେଇଥିଲେ।

6. Scientists-School Students online interaction program: Fifth Session of Physics Open Discussion (POD) at IOP Bhubaneswar

The Fifth Session of the Monthly Physics Open Discussion (POD) online program at IOP Bhubaneswar was held on 15th Jan. 2022 during 5:30 pm – 7 pm. The program was attended by about 80 school students from all over Odisha from class VI to class XII on Zoom online platform. Questions ranging from basic physics concepts (Astronomical measurements by early astronomers, magnetic force, seeing the light, sound generation, nature of gravitational force,...), to frontier areas of physics (quantum entanglement, metric tensor and curvature, shape of planets, lightening, from internet exposure of students) were discussed. Students asked questions in English, Hindi, and Odiya.

YouTube link for the session: https://www.youtube.com/watch?v=rIBlc_1EEsM

7. Popular Science talk at the virtual Science outreach camp "Science Movement" for high school students of Odisha at Cohen International School, Bhubaneswar

A popular science talk on "Origin of the Universe" was given by Prof. A.M. Srivastava on 14th Feb. 2022 at the virtual Science outreach camp "Science Movement" for high school students of Odisha at Cohen International School, Bhubaneswar. The talk and interaction session was held for 2 hours.

8. Scientists-School Students online interaction program: Sixth Session of Physics Open Discussion (POD) at IOP Bhubaneswar

The Sixth Session of the Monthly Physics Open Discussion (POD) online program at IOP Bhubaneswar will be held on 19h Feb. 2022 during 5:30 pm – 6:30 pm. The program was attended by about 20 school students from all over Odisha from class VI to class XII on Zoom online platform. Questions ranging from basic physics concepts (electrical circuits, high voltage current lines, light scattering by gases, polarization of waves,...), to frontier areas of physics (black holes, elementary particles etc. from internet exposure of students) were discussed. Students asked questions in English, Hindi, and Odiya.

9. Ministry of Culture, Govt. of India, organized competitions on Deshbhakti Geet, Lori and Rangoli.

On the eve of Azadi Ka Amrit Mahotsav, Ministry of Culture, Govt. of India, organized competitions on Deshbhakti Geet, Lori and Rangoli. Employees of IOP, Mrs. Saubhagya Laxmi Das, and Dr. S. N. Sarangi, participated in the event and received participation certificate.

10. "Bigyan Sarbatra Pujyate" ", a week-long festival organized by Science and Technology Department of Odisha at KIIT University, Bhubaneswar.

Prof. K. K. Nanda, Director, Institute of Physics, Bhubaneswar was invited as a chief guest in the valedictory function "Bigyan Sarbatra Pujyate", a week-long programme organized by Department of Science and Technology, Odisha as a part of the Azadi Ka Marit Mahostav from February 22-28, 2022 at KIIT university. The festival was celebrated in collaboration with Odisha Bigyana Academy (OBA), Regional Science Centre, Bhubaneswar, City Knowledge Innovation Cluster (BCKIC) and KIIT University. The programme comprised of expositions, popular scientific talks, lecturers, films, science literature activities, books & posters and awards aiming at students, teachers, and researchers from different schools and colleges of Odisha to make them aware about science and scientists. The speech delivered by Prof Nanda in valedictory function emphasized on the career in science and the how the research in science mutualized by different other agencies. He also presented the awards to different participants in the valedictory function.

11. Popular science talk at Berhampur University on the occasion of

National Science Day on 28th Feb 2022

Prof. Shikha Varma presented a popular science talk at Berhampur University on the occasion of National Science Day on 28th Feb 2022. The talk was attended by UG and PG students of Physics, Chemistry, Biology, Maths, computer science, Management etc. The title of the talk was "Excitements in Functional Materials: Nanotechnology to "Nano Bio". The importance and exciting aspects of Nanotechnology in numerous applications was presented to the students.

12. "OPEN DAY" event at Institute of Physics, Bhubaneswar

Each year on 28th February, Institute of Physics (IoP) observes National Science Day (NSD) in its premises. This year, NSD celebration at IoP was planned in a very different manner from previous years by the initiative of Prof. K. K Nanda, Director, IoP. As a part of celebration of National Science Day 2022, IoP organized an "OPEN DAY" event to show-case its activities to the student community, teachers, parents, technology enthusiasts and the general public. The idea of having an "OPEN DAY" at IoP was conceived by Prof. K. K Nanda, from his past long experience about it at IISc, Bangalore. He realized through "OPEN DAY" IoP can reach out to a larger section of students, teachers, parents and public in the local area and create more scientific awareness.

The science activities on "OPEN DAY" at IoP featured live demo experiments, Laboratory visits, poster presentations, and the display of scientific movies. Some of the live demo experiments

(Volunteers at IoP main gate, Laboratory demonstration, Live experiment demonstration, Doordarshan coverage: A byte by Prof. K. K. Nanda, Open Day Flyer)

included Eco house, Invisible flame, Surface tension, Faraday effect and Lenz's Law, Tyndall effect, O_3-based Sanitization, Superconducting Levitation … to kindle curiosity in the minds of young budding talents. Besides, the visitors visited the research laboratory craning their necks to catch a glimpse of sophisticated equipments/experimental set up. Some of these include Ion Beam Laboratory, Advance material Growth Laboratory, Laboratory for Low Dimensional Materials, Surface Nanostructuring and Growth Laboratory, Raman spectrometer, SQUID-Magnetometer, and HEP Detector Laboratory. The event extended from 10:00 am to 05.00 pm on 28th February at the premises of the Institute. Efforts were put in advance to make a wide circulation about the event in various Schools, Colleges, and public places in and around Bhubaneswar and invitations were extended to students, teachers of various schools/colleges to visit, explore and enjoy the scientific activities at IoP during the "OPEN DAY". IoP received an overwhelming response from the visitors, altogether, there were about 600-700 visitors out of which the majority belonged to students community, who were very much excited to look around the scientific happenings at IoP and enjoyed the scientific vibes. A dedicated team comprising of faculty members, scientific staff, administrative staff, PhD students and postdocs who have been instrumental in organizing such outreach scientific activities put all their efforts, time and energy to smoothly organize the event and made it a grand success and memorable one. Some of the photographs and media report on the "OPEN DAY" event at IoP are enclosed below.

13. Popular Articles

Prof. K K Nanda has contributed an article on "Carbon dots based invisible ink" and Prof. Arijit Saha has written an article on "Topological Insulators: A Modern Era of CMP. Both the articles are put in the AKAM webpage link of IOP website. The following are the links for popular articles.

https://www.iopb.res.in/AKAM/Prof_K_K_Nanda_Pop_Art_Invisible_Ink.pdf

https://www.iopb.res.in/AKAM/Topo_Insu_A_Saha.pdf

14. International Women's Day -2022 celebrated at Institute of Physics (IOP), Bhubaneswar on 8th March 2022

On the occasion of the International Women's Day (IWD) talks were arranged by Women-cell of IOP on 8th March 2022. The talks were given by Ms. Rama Sarode, Socio legal Trainer and Prof. Subhra Chakraborty, Director, Plant and Genome Research, N. Delhi. The meeting was held in hybrid mode, with speakers and some IOP members present online and some members present in the lecture hall (block-A) of IOP.

At the outset, Prof. Shikha Varma, Chairperson Women Cell, IOP welcomed everyone and thanked all the distinguished speakers for enthusiastically agreeing for giving talk on this occasion. She thanked

Prof. K.K. Nanda, Director, Mr. R.K. Rath, Registrar, administration, computer center members, all women cell members and all IOP members for their enthusiasm and support. Prof. K.K Nanda, Director, in his address presented the important features of the Women Cell and Internal Complaints Committee (ICC) of IOP. He mentioned about the necessity of equity in various fields. He highlighted the roles and efforts undertaken by IOP scientists in encouraging girls and women towards career in science. Ms. Rama Sarode (Director, MGZ-EDYTECH, PVt. Ltd., Pune), gave a talk on "**Developing an Inclusive Culture to make Safe Workplace**" where she discussed issues related to the safety of women at work place. Prof. Subhra Chakraborty (Director, National Institute of Plant Genome Research, N. Delhi) gave a talk on "Decoding multi-host resistance: Divergent regulatory networks in fungal disease).

(IWD program: IOP members in the lecture hall)

15. Scientists-School Students online interaction program: 7th Session of Physics Open Discussion (POD) at IOP Bhubaneswar.

The 7th Session of the Monthly Physics Open Discussion (POD) online program at IOP Bhubaneswar wass held on 19h March 2022 during 5:30 pm – 6:30 pm. This time program was attended by 9-10 school/college teachers and some researchers (with Holi festival and exams for students) on Zoom online platform. Questions in basic physics concepts related to Newton's laws, circular motion, gravitational potential energy etc. Advanced questions in frontier areas of physics

related to large distance physics of universe, universe expansion, nuclear fission, matter-antimatter asymmetry etc. Questions were asked in English, Hindi, and Odiya.

YouTube link: https://www.youtube.com/watch?v=OofaDg5zyyM&t=2515s.

16. Popular Science Talk in Hindi at Science Awareness Workshop

Prof. A.M. Srivastava participated in the Science Awareness Workshop at Allahabad University on 25th March, 2022. Prof. Srivastava gave a popular science talk in Hindi (with slides prepared in Devanagari) on "Brahmand Ki Sanrachna" (Structure of the Universe). The talk was

अमृत कलश टाइम्स

प्रयागराज रविवार 26 मार्च 2022

इविवि: विज्ञान जागरूकता कार्यशाला का आयोजन

प्रयागराज। डी०एस०टी०– पर्स की योजना सिनर्जेटिक ट्रेनिंग प्रोग्राम यूटीलाइजिंग सांइटिफिक एण्ड टेक्नोलॉजिकल इन्फ्रास्ट्रक्चर (ज्ज्ज्) के अन्तर्गत इलाहाबाद विश्वविद्यालय के भौतिकी विभाग के तत्वावधान में 25 मार्च को दिन में 10 से 2 बजे तक विभाग के ही व्याख्यान कक्ष क्रमांक– 18 में ष्विज्ञान जागरूकता कार्यशालाष् का आयोजन किया गया। इस कार्यक्रम के अन्तर्गत दो व्याख्यान आयोजित किये गये। ब्रह्माण्ड की संरचना इस व्याख्यान में विज्ञान संस्थान, भुवनेश्वर के विख्यात भौतिकी विज्ञानी और पूर्व निदेशक प्रोफेसर अजित मोहन श्रीवास्तव ने ब्रह्माण्ड के उद्भव, आइंस्टाइन का गुरुत्वाकर्षण सिद्धान्त, न्यूटन के नियमों की सीमाओं, गुरुत्वीय तरंगों, आकाशगंगा और नीहारिकाओं का ब्रह्माण्डीय पैमाने पर समांग और समदेशी वितरण, श्याम ऊर्जा (डार्क एनर्जी) ब्रम्हाण्ड का त्वरित प्रसार, बिग–बैंग सिंगुलारिटी क्वान्टम विक्षोभ और आकाशीय संरचनाओं का निर्माण, बिग–बैंग का सूक्ष्म तरंगों के रूप में अवशेष आदि पर सरल व सहज किन्तु गहन चर्चा की। जैम तज वि कमंसपदह पजी जीम द जनतस बंस उपजपमे दक बपमदबम बवउउनदपबंजपवद इस व्याख्यान में प्रोफेसर दिनेश श्रीवास्तव ने कोरोना जैसी महामारी प्राकृतिक व मानवीय विभीषिकाओं के कठिन समय में जनसाधारण को अपने जीवन को संतुलित ढंग से जीने की कला के बारे में अवगत कराया। उन्होंने इस व्याख्यान के माध्यम से बताया कि किस प्रकार विज्ञान ने इन महामारियों से दुनिया को बचाया और आज भी बचा रहा है। प्रोफेसर श्रीवास्तव की इस विषय पर प्रोफेसर राममूर्ति और प्रोफसर शैलेश नायक के बहुचर्चित पुस्तक ।तज दक बपमदबम वउउदहपदह चनइसपब तपो हम सभी को पढ़नी चाहिए। इस व्याख्यान को लेकर इलाहाबाद विश्वविद्यालय के एम०एस०सी० और बी०एस०सी० के विद्यार्थियों में खासी उत्सुकता देखने को मिली। दोनों हाल छात्र–छात्राओं से खचाखच भरे हुए थे जिनमें टेलीकास्टिंग की सहायता से जीवंत प्रसार किया जा रहा था। कार्यक्रम के अन्त में बच्चों ने प्रोफेसर अजित मोहन श्रीवास्तव से बहुतेरे प्रश्न पूछे। कार्यक्रम की अध्यक्षता विज्ञान संकाय के डीन, प्रो० शेखर श्रीवास्तव ने की। कुलपति के प्रतिनिधि के रूप में प्रो० सैयद रिजवी ने कार्यक्रम को अपनी शुभकामना प्रेषित की। कार्यक्रम का संचालन भौतिकी विभाग के विभागाध्यक्ष प्रो० विवेक कुमार तिवारी ने किया। कार्यक्रम में विश्वविद्यालय के वरिष्ठ प्रोफेसर विनोद प्रकाश, प्रो० पंकज कुमार, अध्यक्ष, राजनीति विज्ञान विभाग, प्रो० आई० आर० सिद्दीकी, अध्यक्ष, रसायन विज्ञान विभाग, प्रो० पी० के० टण्डन, प्रो० ए०एन० विश्नोई आदि की प्रेरक उपस्थिति रही। कार्यक्रम को सफल बनाने में विभाग के विभिन्न प्रोफेसरों, अतिथि प्रवक्ताओं, शोध छात्रों की महत्वपूर्ण भूमिका रही। प्रो० लोकेन्द्र कुमार ने वाद–विवाद प्रतियोगिता प्रो० प्रतिमा, ने विज्ञान प्रश्नोत्तरी और प्रो० राजकुमार आनन्द, ने पोस्टर प्रतियोगिता का आयोजन कराया जिसके विजेताओं को प्रमाण पत्र वितरित।

YouTube link: https://www.youtube.com/watch?v=TaqRjvBt6MM

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attended by B.Sc., M.Sc. Students, research scholars, faculty of Physics Dept. and invitees from other Departments.

17. DAE-BRNS Outreach Theme Meeting on "Societal Applications of Nuclear Science and Technology

A DAE-BRNS Outreach Theme Meeting on "Societal Applications of Nuclear Science and Technology" (SANST-2022)" was jointly organized by Department of Atomic Energy (Bhabha Atomic Research Centre), Institute of Physics (IOP), National Institute of Science Education and Research (NISER) and Maharaja Sriram Chandra Bhanja Deo (MSCBD) University, Takatpur, Baripada, Odisha, in association with Indian Association of Nuclear Chemists and Allied Scientists (IANCAS) during March 25-27, 2022 to commemorate Azadi Ka Amrit Mohotsav. The meeting covered domain-specific lectures and demonstration of the products from the concerned experts in DAE. More than 150 participants (mainly faculties of Science disciplines, Research Scholars from various academic/research

(All the dignitaries on dais, Member participated from IOP with Honorable VC MSCB University, Baripada, Inagural speech by Prof. Nanda and talk delivered by Prof. Nanda)

institutes of Odisha) and 25 experts participated in this deliberations. In addition, a few faculties/ researchers participated in the meeting online (virtual) mode. The technical program consisted about 15 keynote/invited talks by experts from DAE followed by two experiments. An Exhibition of Outreach Posters was arranged for the benefit of all participants. Nearby College faculty members and students were invited to visit Outreach posters and interact with the experts from DAE (BARC, IOP and NISER). The deliberations and discussions would be instrumental in enriching the existing knowledge to create strong linkage between technology and innovative policies for the overall societal development and welfare. We thank all experts/resource persons for their timely help and support in giving abstracts of talks and sparing their valuable time. Eminent personalities, Prof. A.K. Mohanty, Director, BARC and Chair, Prof. K. K. Basa, Hon'ble vice chancellor, MSCB University, Baripada. Prof. K. K. Nanda, Director, IOP, Prof. S. Panda, Director, NISER**,** and other dignitaries from BARC, DAE and IOP. Dr. R. Acharya and Dr. P. K. Pujari Dr. A. K. Tyagi, Dr. S. M. Yusuf, Shri S. K. Jakhotiya, Dr. T. K. Ghanty, Shri M.K. Sapra, Smt. Smita S. Mule, Dr.Soumitra Kar & Shri A. K. Adak, Dr. Raghunath Acharya, Dr. Prasun K. Mukherjee and T. R. Ganapathi, Dr. S. Gautam, Dr. B. K. Das, Dr. Pawan Kumar Agrawal, Prof. P. K. Sahu, Dr. S. N. Sarangi & Dr. B. Mallick delivered their talk on the Societal Applications of Nuclear Science and Technology. MSCB University, Baripada, extended all possible support and cooperation in making this Outreach Theme Meeting a reality.

18. Popular Articles

Prof. Saptarshi Mandal has contributed a popular article on "Story of metal, semiconductor and insulator". The following is the links for this popular article.

https://www.iopb.res.in/AKAM/Saptarshi-AKAM.pdf

4.4. Sports and Cultural Activities

Along with the research activities, the sports and cultural activities have been promoted through different sports and cultural programs to keep all the members physically fit. To carry out different sports and cultural activities a committee was formed. The committee members are: Prof. S. K. Patra (Chairman), Prof. T. Som, Dr. S.Mandal, Dr. A.K.Nayak, Sri B. Behera (Convener), Sri P.K.Senapati, Sri. B. K.Dash.

Followings are the different activities conducted during the year 2021-22:

1. A Football match was conducted on 15th August, 2021. This was a friendly match between Team A (Faculties and Doctoral scholars) and Team B (Staffs of the Institute). The match was tie. Around 110 spectators were there to enjoy the football match.

2. Also a friendly Cricket match was conducted on the occasion of 26th January, 2022. This match was played between Team A (Faculties and Doctoral scholars) and Team B (Staffs of the Institute). It was a very interesting match. The match was ended with draw. Around 80-viewers joined and made the event successful.

3. For the COVID-19 pandemic, to maintain social and physical distancing most of Sports and Cultural activities were disturbed during this year. However many activities had been conducted in other occasions.

FACILITIES

5.1 MAJOR EXPERIMENTAL FACILITIES

Ion Beam Facilities

The Ion Beam Laboratory houses the NEC 3 MV tandem Pelletron Accelerator which is one of the major facilities used by researchers from all over the country. The accelerator provides ion beams of energies typically 1-15 MeV starting from protons and alphas to heavy ions. Commonly used ion beams are that of H, He, C, N, Si, Mn, Ag and Au. Multiple charge states are possible for the MeV energy positive ion beams. Argon is used as the stripper gas to produce positive ions. The most probable charge state for heavy ions (carbon or above) is 3+ for terminal potentials above 2 MV.

The beam hall has six beam lines. The beam line at -45° is used for Rutherford Backscattering (RBS), Elastic Recoil Detection Analysis (ERDA), Proton induced X-ray Emission (PIXE), Ultra high vacuum (UHV) and ion channeling. A general purpose scattering chamber suitable for PIXE experiments is available in the 0° line. This beam line also has the potential to perform external PIXE experiments in atmosphere. The 15° beam line is equipped with a raster scanner and is being used for ion implantation. There is a UHV chamber for surface science experiments in the 30° beam line. The 45° beam line houses the micro-beam facility.

The electron cyclotron resonance (ECR) ion source for ion implantation, nanoscale patterning, ion-beam induced epitaxial crystallization, ion-beam mixing, ion-beam shaping, and synthesis of embedded nanostructures and so on. At Surface Nano structuring and Growth (SUNAG) Laboratory, we have facilitated a low energy (50 eV – 2 keV), broad beam (I in. diameter) electron cyclotron resonance (ECR) source based ion beam etching facility for creating self-organized surface nanostructures.

Microscopy Facilities

The High Resolution Transmission Electron Microscope (HRTEM) facility consists of two components: Jeol 2010 (UHR) TEM and Associated Specimen Preparation system. High-Resolution Transmission Electron Microscopy (HRTEM) with an ultra-high resolution pole-piece (URP22) working at 200 keV electrons from LaB6 filament assures a high quality lattice imaging with a point-point to resolution of 0.19 nm.

Arups Facilities

The Angle Resolved Ultraviolet Photoelectro Spectrometer (ARUPS) is equipped with facilities for doing both angle integrated valence band measurements as well as angle resolved valence band measurements. The angle resolved studies are possible on single crystals.

Pulsed Laser Deposition (PLD) System

PLD system helps growing epitaxial thin films of various materials albeit the most preferred materials are oxides. The newly installed system was developed in a piece-wise manner by procuring several modules from different sources. We are depositing epitaxial bi- and multi-layer thin films of superconducting (viz. YBCO) and colossal magneto-resistance (viz. LSMO) on suitable substrates.

Magnetic Property Measurement Facility

The SQUID-VSM lab consists of the Quantum Design MPMS SQUID-VSM

EVERCOOL system. The magnetic property measurement system (MPMS) is a family of analytical instruments configured to study the magnetic properties of samples over a broad range of temperatures and magnetic fields. Extremely sensitive magnetic measurements are performed with superconducting pickup coils and a Superconducting Quantum Interference Device (SQUID).

Optical Property Measurement Facility

The Micro Raman facility is operated in backscattering geometry. Confocal mapping capabilities with sub-micron spatial resolution are possible. A wide range of excitation wavelengths, using laser, is possible allowing control of the penetration depth into the material, and thus, control of the volume sampled.

5.2 COMPUTER FACILITY

The computer centre facilitates the scientific community dedicatedly in terms of scientific computation and In-House IT facilities. The centre is responsible for managing information and communication technology infrastructure in the Institute. The centres activity ranges from administration (server, network, etc.), hosting various services to laptop/desktop & user support. The Centre provide support in a hybrid environment consisting of different operating systems such as Unix-based (Cent OS, Redhat, Fedora, Ubuntu), MS Windows and MAC OS. Our Data centre activities has a state-of-art mechanism to handle system administration which includes mail services, centralized storage solution with backup facility and in-House development of web and intranet and gigabit network connectivity. In order to accomplish our Data centre activities, we have installed high end servers, core, distribution, access layer network switches, Firewall (UTM) and load balancer. Wireless network is available across all the buildings in campus. Internet facility is extended to residence area through Asynchronous Data Subscriber Line (ADSL). The center conducts training, workshop and awareness programs in relevant areas time to time.

5.3 SAMKHYA (सांख्य): High Performance Computing Facility (HPC)

SAMKHYA (सांख्य) - High Performance Computing (HPC) Facility at Institute is a hybrid environment which consists Sixty (60) Compute Nodes, two (2) Master Nodes, Four (4) I/O nodes (OSS & MDS) and 50 TB of object storage, QDR Infiniband interconnect and 1 Gbps Local Area Network. The infrastructure is of two (2) precision AC (10 ton of refrigeration each) and uninterrupted supply through three (3) 40KVA & one (1) 60 KVA UPS to facilitate the system. The facility consists of 1440 CPU cores, 40 NVIDIA Tesla K80 cards and 40 Intel Xeon Phi 7120P.

This facility has been ranked in the list of top supercomputers in India by CDAC, Bengaluru (January 2018 report at http://topsc.in).

5.4 ANUNET FACILITY

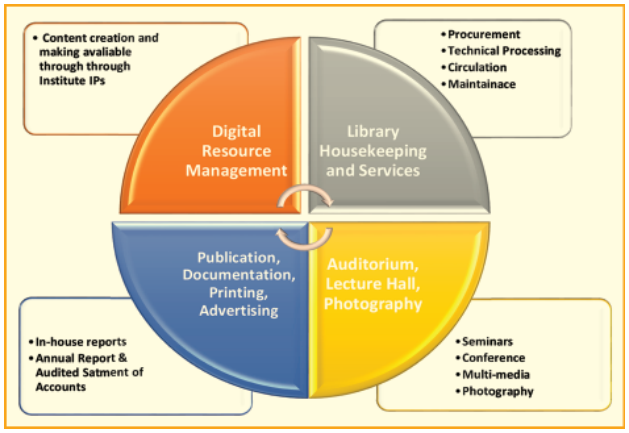
Institute of Physics is a node on ANUNET with the provision to connect other units of DAE directly by VSAT link for voice and data communication. Seismic monitoring equipment has been installed in the Institute and seismic data

is being continuously transmitted to Bhabha Atomic Research Centre (BARC) for analysis using ANUNET. The link is also used to connect with DAE and other institute on ANUNET through video conferencing setup.

In addition to members of the Institute, computer facility is also being used by Researchers of several other universities and colleges in Odisha for their academic work.

5.4. LIBRARY

The IOP Resource Center's mandate is to select, acquire, process, and disseminate print and electronic/digital scientific and technical resources for the research community and other visiting users. On the other hand, IOP General Library aims to serve the IOP community's requirements and nurture the reading habit. Apart from the day-to-day Library services, IOP Library also provides associated facilities: reprography, printing, publishing, advertising, photography, videography, document delivery, and an auditorium with lecture hall services. Besides these other related activities, such as conferences/seminars, IOP Library also conducts outreach programs. The operations of the IOP Library are depicted in the figure.



The Library facility is available to the members of the Institute as well as members from other academic institutions of the State, especially Institutes under the Department of Higher Education of Government of Odisha. The detailed holdings of the Library can be accessed from Library Portal @ http://www.iopb.res.in/~library.

The Library facility is available to the members of the Institute as well as members from other academic institutions. The Library holdings include 17500+ books, 6000+ e-books, and 23,643 bound Journals as its collection. The Library subscribes to 135 e-journals and some print Journals/Magazines and Newspapers. The Library has also acquired IOP (UK), John Wiley, Springer Physics and Astronomy, Scientific American, World Scientific, Annual Reviews Archives (OJA) perpetual access right to the back files containing all articles published since Volume 1 in electronic format. Library also subscribes to e-Books on Lecture Notes in Mathematics and Physics series from Volume1 with perpetual access to backfiles and complete archive. Being a core member of the Department of Atomic Energy (DAE) Consortium with Elsevier Science, Library is also getting access to selective Elsevier journals with access from 1995 onwards electronically.

1. Librarian, Dr. B. Mohanty giving an orientation program on IOP Library resources and various tools to the Ph.D. batch 2021; 2, 3 & 4. Field visit of MLIS students of Berhampur & Sambalpur University students).

Library subscribes to the iThenticate (Anti-Plagiarism Web Tool) for assuring the Academic Integrity of the Institute and is accessible over Institute IP ranges through the library portal at: http://www.iopb.res.in/~library/plagiarism.php. Library also subscribes to "Grammarly Tool" (a proprietary research writing software and citation audit tool delivered on Cloud as a software service by Grammarly Inc., USA).

The Library assists users in obtaining articles from other libraries under the resource sharing programme. The Library also sends articles as Digital Inter-Library Loan (*dill@iopb.res.in*) on request for academic purposes. The IOP Library was the first Library in Odisha which was automated through Integrated Library Management System (ILMS). It is then migrated to RFID-based Smart Library Solution through KOHA Library Management System (LMS). It supports most library housekeeping activities like Acquisition, Cataloguing, Circulation, and Serial Control with auto check-in and check-out facilities. Searching for books and Journals can be done using the Library WEB-OPAC @ (https://www.iopb.res.in/~library/ > http://10.0.1.16/).

Library also handles the publication, printing and advertisement (PRD) division of the Institute and provides reprographic services. In order to spread the awareness among the Scientists and Research Community of IOP for the smooth functioning and proper utilization of all e-resources/technology-enabled services, training-cum-demo sessions are also being organized at the periodic interval. The Library also supports many extension services, namely Study Tour of LIS students and Project/Dissertations of LIS students.

5.6 AUDITORIUM

IOP has a beautiful auditorium on its campus for organizing Colloquiums, Seminars, Workshops, Conferences, Cultural activities, Social programs regularly. This auditorium has all the high-quality amenities and can accommodate 330+ people.

PERSONNEL

PERSONNEL

DIRECTORS

1. Prof. Karuna Kar Nanda
Director (From 16.06.2021 A.N.)

2. Prof. S. M. Yusuf
Director (Till 16.06.2021 F.N.)

6.1. List of Faculty members and their research specialization

1. **Prof. Ajit Mohan Srivastava**
   Professor
   High Energy Physics (Theory)
2. **Prof. Shikha Varma**
   Professor
   Condensed Matter Physics (Experiment)
3. **Prof. Pankaj Agrawal**
   Professor
   High Energy Physics (Theory)
4. **Prof. Biju Raja Sekhar**
   Professor
   Condensed Matter Physics (Experiment)
5. **Prof. Sudipta Mukherji**
   Professor
   High Energy Physics (Theory)
6. **Prof. Suresh Kumar Patra**
   Professor
   Nuclear Physics (Theory)
7. **Prof. Tapobrata Som**
   Professor
   Condensed Matter Physics (Experiment)
8. **Dr. Goutam Tripathy**
   Reader-F
   Condensed Matter Physics (Theory)
9. **Prof. Pradip Kumar Sahu**
   Professor
   Nuclear High Energy Physics (Theory & Experiment)
10. **Prof. Dinesh Topwal**
    Associate Prof.
    Condensed Matter Physics (Experiment)
11. **Prof. Sanjib Kumar Agarwalla**
    Associate Professor
    High Energy Physics (Theory)
12. **Prof. Arijit Saha**
    Associate Prof.
    Condensed Matter Physics (Theory)
13. **Prof. Saptarshi Mandal**
    Associate Prof.
    Condensed Matter Physics (Theory)
14. **Prof. Satyaprakash Sahoo**
    Associate Prof.
    Condensed Matter Physics (Experiment)
15. **Prof. Aruna Kumar Nayak**
    Associate Prof.
    High Energy Physics (Experiment)
16. **Prof. Debashis Chaudhuri**
    Associate Prof.
    Condensed Matter Physics (Theory)
17. **Prof. Shamik Banerjee**
    Associate Prof.
    High Energy Physics (Theory)
18. **Prof. Debakanta Samal**
    Associate Prof.
    Condensed Matter Physics (Experiment)
19. **Dr. Debottam Das**
    Reader - F
    High Energy Physics (Theory)
20. **Dr. Manimala Mitra**
    Reader - F
    High Energy Physics (Theory)
21. **Dr. Kirtiman Ghosh**
    Reader - F
    High Energy Physics (Theory)

6.2. Inspire/Visiting Faculty

1. Dr. Kuntala Bhattacharjee
2. Dr. Aparajita Mandal
3. Dr. B. K. Panigrahi
4. Dr. Chhatrasal Shalikram Gayner

6.3. Post-Doctoral Fellows

1. Dr.Hanuma Kumar
2. Dr. Paramita Maiti
3. Dr. Akavoor Manu
4. Dr. Karan Singh
5. Dr. K.G. Paulson
6. Dr. Dibyakrupa Sahoo
7. Dr. Anjan Kumar Jena
8. Dr. R. Bhattacharyya
9. Dr. Rakesh Kumar Sahoo
10. Dr. S. S. Khali
11. Dr. Siddharth Dwivedi
12. Dr. Krishnanu Sadhukhan
13. Dr. Soumya C (NPDF)

6.4. Doctoral Scholars

1. Suman Roy
2. Raju Mandal
3. Sharmistha Chattopadhyay
4. Manish Patel
5. Aswin Kumar Burma
6. Pujalin Biswal
7. Kamalesh Bera
8. Amartya Pal
9. Ithineni Sairam
10. Rameswar Sahu
11. Sanu Varghese
12. Sheikh Moonsun Pervez
13. Subhadip Bisal,
14. Debasish Mondal
15. Dipak Maity
16. Digbijaya Palai,
17. Abhishek Roy
18. Aisha Khatun
19. Ankit Kumar
20. Arnob Kumar Ghosh
21. Arpan Sinha
22. Chitrak Karan
23. Harish Chandra Das
24. Mousam Charan Sahu
25. Pragyanprasu Swain
26. Ritam Kundu
27. Sameer Kumar Mallik
28. Sandhyarani Sahoo
29. Siddharth Prasad Maharathy
30. Sudipta Das
31. Bibhabasu De
32. Diwakar
33. Pranjal Pandey
34. Rupam Mandal
35. Saiyad Ashanujjaman
36. Rojalin Padhan

37. Gupteswar Sabat,
38. Abhisek Bag
39. Avnish
40. Debjyoti Majumdar
41. Sayan Jana
42. Subhadip Jana
43. Vinaykrishnan M.B.
44. Sudarshan Saha
45. Alapan Dutta
46. Amir Shee
47. Dibyendu Rana
48. Dilruba Hasina

6.5. Project Doctoral Fellows

1. Anil Kumar (*INO Proj. Student*)
2. Sadashiv Sahoo (*INO Proj. Student*)

6.6. ADMINISTRATIVE PERSONNEL

Shri R. K. Rath, Registrar

(i) Director's Office:

1. Bira Kishore Mishra
2. Lipika Sahoo
3. Rajan Biswal
4. Sudhakar Pradhan

(ii) Registrar's Office

1. Rajesh Mohapatra
2. Abhimanyu Behera

(iii) Establishment

1. M.V. Vanjeeswaran
2. Bhagaban Behera
3. Baula Tudu
4. Soubhagya Laxmi Das
5. Raj Kumar Sahoo
6. Samarendra Das
7. Ranjit Pradhan
8. Pradip Kumar Naik
9. Gandharba Behera

(iv) Stores & Transport

1. Pramod Kumar Senapati
2. Sanatan Jena
3. Sarat Chandra Pradhan
4. Jahangir Khan
5. Keshaba Chandra Dakua
6. D. Govinda Rao (*upto Feb-2022*)

(v) EPABX

1. Arakhita Sahoo
2. Daitari Das

(vi) Accounts

1. Debendranath Sahoo
2. Bhaskar Mishra *(upto 30.09.2021)*
3. Prativa Choudhury
4. Priyabrata Patra
5. Rajesh Mohapatra
6. Abhisek Maharik
7. Purabi Paramita
8. Jyoti Ranjan Behera
9. Bijay Swain
10. Bijaya Kumar Das

(vii) Maintenance

1. Arun Kanta Dash
2. Debaraj Bhuyan
3. Bansidhar Behera *(D.O.D. 29.06.2021)*
4. Brundaban Mohanty
5. Deba Prasad Nanda
6. Naba Kishore Jhankar
7. Umesh Ch. Pradhan *(D.O.D. 08.10.21)*
8. Biswa Ranjan Behera *(D.O.R. 31.03.22)*
9. Kapila Pradhan
10. Martin Pradhan
11. Chandra Mohan Hansdah

(viii) Estate Management

1. Saroj Kumar Jena.
2. Gangadhar Hembram (upto 31.05.2021)
3. Tikan Kumar Parida
4. Biswanath Swain
5. Bijaya Kumar Swain (01.10.21)
6. Sanatan Pradhan
7. Bhaskara Mallick
8. Kulamani Ojha
9. Pitabas Barik
10. Dhoba Naik
11. Charan Bhoi
12. Jatindra Nath Bastia
13. Basanta Kumar Naik
14. Ramakanta Nayak
15. Ramesh Kumar Patnaik

(ix) Library

1. Dr. Basudev Mohanty
2. Ajita Kumari Kujur
3. Rama Chandra Hansdah
4. Kisan Kumar Sahoo
5. Kailash Chandra Jena

(x) Computer Centre

1. Makrand Siddhabhatti
2. Nageswari Majhi
3. Arakhit Sahoo

(xi) Laboratory

1. Sanjib Kumar Sahu
2. Dr. Sachindra Nath Sarangi
3. Khirod Chandra Patra
4. Madhusudan Majhi
5. Ramarani Dash
6. Santosh Kumar Choudhury
7. Dr. Biswajit Mallick
8. Pratap Kumar Biswal
9. Bala Krushna Dash
10. Soumya Ranjan Mohanty
11. Purna Chandra Marndi
12. Srikanta Mishra
13. Ranjan Kumar Sahoo

(xii) Workshop

1. Subhabrata Tripathy

(xii) Purchase Section

1. Aviram Sahoo
2. Ghanashyam Pradhan

6.7. List of New Members :

Shri Ranjit Pradhan
Designation: Lower Divison Clerk
DoJ: 14.12.2021

Smt. Purabi Paramita
Designation: Lower Divison Clerk
DoJ: 02.03.2022

6.8. List of Retired Members

Shri Gangadhar Hembram
Designation: Tradesman-A
DoJ: 29.04.1982
DoR: 31.05.2021

Shri Bhaskara Mishra
Designation: Senior Assistant
DoJ: 27.12.1995
DoR: 30.09.2021

Biswaranjan Behera
Designation: MTS/B
DoJ: 15.07.2002, DoR: 31.03.2022

परीक्षित लेखा विवरण
AUDITED STATEMENT OF ACCOUNTS
2021-22

भौतिकी संस्थान
INSTITUTE OF PHYSICS

भुवनेश्वर, ओडिशा

BHUBANESWAR, ODISHA

जीआरसी एंड एसोसिएट्स / GRC & Associates

सनदी लेखाकार / Chartered Accountants

एन-6/432, पहली मंजिल, आईआरसी गांव, नयापल्ली,

N-6/432, 1st Floor, IRC Village, Nayapalli,

भुवनेश्वर, ओडिशा, पिन - 751015

Bhubaneswar, Odisha, Pin - 751015

Contents

N-6/432, 1st Floor, IRC Village, Nayapalli,
Bhubaneswar, Odisha, Pin - 751015
Ph : 674-2362263, 2362265
Cell : 9437064902, 9777999902, 9437113710
Email : grc.bbsr@gmail.com

GRC & ASSOCIATES
Chartered Accountants

INDEPENDENT AUDITORS' REPORT

To
The Director,
Institute of Physics,
Bhubaneswar.

Report on the audit of the financial statements

We have audited the accompanying financial statements of **INSTITUTE OF PHYSICS** ("the Society"), which comprise the balance sheet as at March 31, 2022, and the Statement of Income and Expenditure and the statement Receipt and Payment for the year ended as on that date.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation of the financial statements that give a true and fair view of the financial position, financial performance of the Society in accordance with the applicable Accounting Standards and Societies Registration Act 1860. This responsibility includes the design, implementation and maintenance of the internal control relevant to the preparation of the financial statements that are free from material misstatement, whether due to fraud or error.

Auditor's responsibility

Our responsibility is to express an opinion on these financial statements based on our audit. We conducted our audit in accordance with the standards on auditing issued by the Institute of Chartered Accountants of India. Those standards require that we comply with ethical requirements and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

An audit involves performing producing procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedures selected depend on the auditor's judgment, including the assessment of the risk of material misstatement of the financial statements, whether due to fraud or error. In making preparation and fair representation of the financial statements in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the appropriateness of accounting polices used and the reasonableness of the accounting estimates made by the management, as well as evaluating the overall presentation of the financial statements.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

GRC & Associates Bhubaneswar Chartered Accountants

Qualified opinion

Basis of Qualification:

1.

a) The Society has not followed IAS 10 for accounting of Fixed assets and AS 6 for provision of depreciation. The society has not maintained fixed assets register to verify the individual asset residual value. Depreciation has been charged on gross block at the end of the year on SLM method irrespective of the fact that individual old assets may have been depreciated in full. The depreciation on assets purchased during the year was also charged for the whole year instead of proportionate basis from date to use.

b) The Fixed Assets of the Society were not physically verified in full during the year under audit.

c) None of the Fixed Assets of the Society were tested for impairment in accordance with IAS 28 and no provision has been made for impairment if any.

2. IAS 12 on accounting of Government grants has not been followed. The grants have been recognized on realization basis. Capital grants have been recognized as capital fund and shown as Liability.

3. The Capital Fund of the Institute is decreased and current Liabilities is increased to the tune of Rs132.22 lakhs to due recognition of unutilised Government grant as current liabilities at the end of the year.

Emphasis of Matter :

Attention of the management is also drawn on the following matter:

Balances of advances and liabilities to/from third parties are subjects to confirmation.

Based on the above, in our opinion and to the best of our information and according to the explanations given to us, the financial statement read with the Accounting policies and note on accounts and the separate report annexed herewith the report, gives the information required by the Act in the manner so required and give a True and Fairview in conformity with the Accounting Principles Generally Accepted in India.

a. In the case of Balance sheet of the state of affairs of the Society as at March 31 2022
b. In the case of the statement of income and expenditure, of the deficit of the institute for the year ended on that date.
c. In case of statement of receipt and payments, the receipts and payment for the year ended on the date.

GRC & Associates Bhubaneswar Chartered Accountants

Report on other legal and regulatory requirements

(a) We have obtained all the information and explanations which to the best of our knowledge and belief were necessary for the purposes of our audit and have found them to be satisfactory.

(b) In our opinion proper books of account as required by law have been kept by the Institute, so far as it appears from our examination of those books.

(c) The Balance Sheet, the Statement of income and Expenditure and Receipts and payment dealt with by this report are in agreement with the books of accounts.

For GRC & Associates
Chartered Accountants
Firm Registration No.02437S

CA A Mohapatra
Partner
MembershipNo.055285
UDIN:22055285ALSQXI5139

Place: Bhubaneswar
Date: The 27th Day of June, 2022

GRC & Associates Bhubaneswar Chartered Accountants

INSTITUTE OF PHYSICS
Sachivalaya Marg, Bhubaneswar

Balance Sheet as at 31st March 2022

(Amount in Rupees)

SOURCES OF FUNDS	Schedule	Current Year	Previous Year
CORPUS/ CAPITAL FUND AND LIABILITIES			
CORPUS/ CAPITAL FUND	1	48,25,21,728	57,99,14,871
RESERVES AND SURPLUS	2	-	-
EARMARKED/ENDOWMENT FUNDS	3	2,11,40,209	2,28,45,629
SECURED LOANS AND BORROWINGS	4	-	0
UNSECURED LOANS AND BORROWINGS	5	-	0
DEFFERED CREDIT LIABILITIES	6	-	0
CURRENT LIABILITIES AND PROVISIONS	7	19,14,35,912	16,34,58,804
TOTAL		**69,50,97,849**	**76,62,19,304**

APPLICATION OF FUNDS	Schedule	Current Year	Previous Year
ASSETS			
PROPERTY,PLANT & EQUIPMENTS	8	65,48,82,707	70,19,88,788
INVESTMENTS FROM EARMARKED/ ENDOWMENT FUNDS	9	0	0
INVESTMENTS OTHERS	10	0	0
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	4,02,15,142	6,42,30,516
TOTAL		**69,50,97,849**	**76,62,19,304**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

As per our attached report of even date

For and on behalf of
GRC & Associates
Chartered Accountants
FRN-002437S

CA Mohapatra
Partner
M.No. 055285
UDIN: 22055285ALSQXI5139
Place: Bhubaneswar
Date: The 27th Day of June 2022

GRC & Associates Bhubaneswar Chartered Accountants

For and on behalf of
Institute of Physics, Bubaneswar

(Mr. D. N. Sahoo)
Jr. Accounts Officer
कनिष्ठ लेखा अधिकारी/JUNIOR ACCOUNTS OFFICER
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

(Mr. R. K. Rath)
Registrar
रेजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

(Prof. K. K. Nanda)
Director
निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS
Sachivalaya Marg, Bhubaneswar

STATEMENT OF INCOME AND EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2022

(Amount in Rupees)

Particulars	Schedule	Current Year (2021-22)	Previous Year (2020-21)
INCOME			
Income from sale or services	12		
Grants/ Subsidies	13	31,31,00,000	26,66,00,000
Fees/ Subscriptions	14	0	0
Income from investments	15	0	0
Income from royalty, Publication etc	16	0	0
Interest Earned	17	2,18,469	16,279
Other Income	18	6,67,236	13,50,149
Increase decrease in stock of finised goods/ WIP	19	0	0
TOTAL (A)		**31,39,85,705**	**26,79,66,428**
EXPENDITURE			
Establishment Expenses	20	25,00,98,281	22,41,08,091
Other Administrative Expenses etc.	21	9,48,79,204	9,13,12,562
Expenditure on grants Subsidies etc (Plan grant Surrendered)	22	0	0
Interest Paid	23	0	0
Depreciation (Corresponding to Schedule 8)		5,42,45,400	5,47,90,802
TOTAL (B)		**39,92,22,885**	**37,02,11,454**
Balance being excess of Expenditure over Income (A-B)		(8,52,37,180)	(10,22,45,026)
Unspent Grant at year end		1,32,22,000	0
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/ CAPITAL FUND		**(9,84,59,180)**	**(10,22,45,026)**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

As per our attached report of even date

For and on behalf of
GRC & Associates
Chartered Accountants
FRN-002437S

CA Mohapatra
Partner
M.No. 055285
UDIN: 22055285ALSQXI5139
Place: Bhubaneswar
Date: The 27th Day of June 2022

GRC & Associates * Chartered Accountants * Bhubaneswar

For and on behalf of
Institute of Physics, Bubaneswar

(Mr. D. N. Sahoo)
Jr. Accounts Officer
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भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

SCHEDULE 1 -CORPUS/CAPITAL FUND

(Amount in Rupees)

Particulars	Current Year (2021-22)		Previous Year (2020-21)	
Balances as at the beginning of the year		57,99,14,871		64,15,57,802
Add : Contributions towards Corpus/Capital Fund	10,66,038		4,06,02,095	
Add/(Deduct) : Balance of Income/(Expenditure) transferred from Income & expenditure Account	-9,84,59,180.28	-9,73,93,142	-10,22,45,026	-6,16,42,931
Balances as at the year end		48,25,21,728		57,99,14,871

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GRC & Associates Bhubaneswar Chartered Accountants

INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

SCHEDULE 3 - EARMARKED/ENDOWMENT FUNDS

(Amount in Rupees)

	Particulars	Current Year (2021-22)				Previous Year
		OB	Receipt	Payment	CB	(2020-21)
1	L.K.Panda Memorial Fellowship SB A/C No.10164207776	1,33,598	6,288	10,000	1,29,886	1,33,598
2	TPSC Account SB A/C No. 450502010004886	1,04,566	3,145	-	1,07,711	1,04,566
3	JC Bose of Prof. A.M.Jayannavar SB A/C No.15987	11,41,814	5,59,141	2,50,000	14,50,955	11,41,814
4	JC Bose of Prof. S.M.Bhattacharjee SB A/C No.16376	2,998	91	47	3,042	2,998
5	Inspire Grant of Dr. S.K.Agarwalla SB A/C No.17400	2,883	97	2,980	-	2,883
6	CSIR Pool Scientist Programme SB A/C No.18179	7,923	243	94	8,072	7,923
7	UGC-DAE CSR Grant SB A/C No.18489	2,01,341	8,098	-	2,09,439	2,01,341
8	RAMANUJAN FELLOWSHIP DR. A.K. NAYAK SB A/C No.18511	1,605	23	1,604	24	1,605
9	INSA PROF. J MOHARANA SB A/C No.18532	22,184	79,456	-	1,01,640	22,184
10	BI-IFCC Grant of Dr. P.K. Sahu SB A/C No.18597	6,80,003	29,278	9,264	7,00,017	6,80,003
11	Inspire Grant of Dr. Manimala Mitra SB A/C No.18695	2,13,875	6,434	98,177	1,22,132	2,13,875
12	SERB Grant of Dr. D. Chaudhuri SB A/c No. 18699	8,55,091	30,683	8,85,774	-	8,55,091
13	DST Grant of Prof. S. Verma SB A/C No.18704	4,65,149	5,32,448	9,97,566	31	4,65,149
14	Woman Scientist Grant of Dr. S. Bandopadhyay SB A/C No.18717	14,219	327	14,546	-	14,219
15	MAX PLANCK GROUP DR. DEBAKANTA SAMAL SB A/C No. 18738	47,60,634	2,01,379	7,00,920	42,61,093	47,60,634
16	INSA YOUNG SCIENTIST SCHEME BY DR. SK AGRAWAL SB A/C No. 18952	4,17,708	11,363	2,66,171	1,62,900	4,17,708
17	NALCO Project - Prof. P.V. Satyam SB A/C No.19051	2,755	4,39,008	1,56,156	2,85,607	2,755
18	DST PROJECT OF PROF PANKAJ AGRAWAL SB A/C No. 19123	18,69,116	59,500	5,69,163	13,59,453	18,69,116
19	PMFS SB A/C No.19143	25,18,375	21,62,714	43,49,625	3,31,464	25,18,375
20	DST PJ TO DR. K BHATTACHARJEE,IIST SB A/C No. 19182	22,38,200	35,11,510	32,39,205	25,10,505	22,38,200
21	DST PROJECT OF DR. SHAMIK BANERJEE SB A/C No.19296	89,618	2,771	35,964	56,425	89,618
22	IOP PROJECT PRENMM&CE-SERB DR.K. GHOSH SB A/C No. 19314	6,31,944	19,638	49,240	6,02,342	6,31,944
23	IOP-PJ-SAP"&F-SERB DR. DEBASISH CHOUDHURI SB A/C No.19315	34,585	1,81,677	1,03,330	1,12,932	34,585
24	IOP SERB PROJECT DR SOUMYA C SB A/C No. 19316	4,97,399	1,63,933	6,56,183	5,149	4,97,399
25	SERB PROJECT OF DR. DEBAKANTA SAMAL SB A/C No.19348	21,94,818	67,416	1,74,142	20,88,092	21,94,818
26	SWARNAJAYANTI FELLOWSHIP DR. SK AGARWALLA SB A/C No.19387	2,32,509	4,037	2,25,251	11,295	2,32,509
27	IOP INSPIRE FACULTY FELLOWSHIP OF A MANDAL SB A/C No. 19497	18,81,452	22,10,513	19,91,138	21,00,827	18,81,452
28	IOP SERB PROJECT OF DR. DINESH TOPWAL SB A/C No.19498	8,37,168	20,22,215	22,64,859	5,94,524	8,37,168
29	SERB PROJECT OF DR. SATYAPRAKASH SAHOO SB A/C No.19506	7,92,100	20,642	1,34,124	6,78,618	7,92,100
30	IOP-SERB-LBSMPNE PROJECT OF DR. SK AGARWALLA SB A/C No.19539	-	20,43,279	8,91,269	11,52,010	-
31	CEFIPRA PROJECT OF DR. MANIMALA MITRA SB A/C No. 19540	-	8,48,746	3,69,261	4,79,485	-
32	IOP-PJ-SJF-SAFPH DR.SHAMIK BANERJEE SB A/C No.20244	-	15,14,540	-	15,14,540	-
TOTAL		**2,28,45,629**	**1,67,40,633**	**1,84,46,053**	**2,11,40,209**	**2,28,45,629**

GRC & Associates Bhubaneswar Chartered Accountants

कनिष्ठ लेखा अधिकारी/JUNIOR ACCOUNTS OFFICER
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निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

SCHEDULE 8- PROPERTY,PLANT & EQUIPMENTS

(Amount in Rs.)

DESCRIPTION	Rate of Depreciation	GROSS BLOCK				Residual Value	DEPRECIATION				NET BLOCK	
		Cost/valuation As on 01.04.2021	Additions	Deduction	Cost/ valuation as on 31.03.2022		Opening Balance as on 01.04.2021	For the Year	On Deduction	Closing Balance as on 31.03.2022	As on 31.03.2022	As on 01.04.2021
A. PROPERTY,PLANT & EQUIPMENTS (PLAN):												
1 LAND:		-		-	-		-	-	-	-	-	-
a) Leasehold		50,00,000.00		-	50,00,000		-	-	-	-	50,00,000	50,00,000
2 BUILDINGS:		-		-	-		-	-	-	-	-	-
a) On leasehold Land	1.63%	21,09,86,379.00		-	21,09,86,379	1,05,49,319	5,71,19,691	34,39,078	-	6,05,58,769	15,04,27,610	15,38,66,688
3 ROADS	1.90%	65,48,158.00		-	65,48,158	3,27,408	62,20,750	-	-	62,20,750	3,27,408	3,27,408
4 PLANT MACHINERY & EQUIPMENT	5.28%	90,03,41,762.70	4,27,721	-	90,07,69,484	4,50,38,474	50,29,87,208	4,75,60,629	-	55,05,47,837	35,02,21,647	39,73,54,555
5 COMPUTER/PERIPHERALS	16.21%	15,11,78,313.00	-	-	15,11,78,313	75,58,916	14,24,45,238	-	-	14,24,45,238	87,33,075	87,33,075
6 Capital Work In Progress		7,20,48,124.00	59,05,036	-	7,79,53,160	7,79,53,160	-	-	-	-	7,79,53,160	7,20,48,124
7 Advance for capital Goods		2,28,702.00	-		2,28,702	2,28,702	-			-	2,28,702	2,28,702
TOTAL(A)		1,34,63,31,439	63,32,757	-	1,35,26,64,196	14,16,55,979	70,87,72,887	5,09,99,707	-	75,97,72,594	59,28,91,602	63,75,58,552
B. PROPERTY,PLANT & EQUIPMENTS (NON-PLAN)												
1 VEHICLES	9.50%	28,70,817.00	-	-	28,70,817	1,43,541	27,50,321		-	27,50,321	1,20,496	1,20,496
2 FURNITURE, FIXTURES	9.50%	2,34,22,316.00	5,70,577	-	2,39,92,893	11,99,645	2,22,51,200		-	2,22,51,200	17,41,693	11,71,116
3 OFFICE EQUIPMENT	9.50%	13,00,86,130.00	2,35,985	-	13,03,22,115	65,16,106	12,30,42,092	22,419	-	12,30,64,511	72,57,604	70,44,038
4 ELECTRIC INSTALLATIONS	6.33%	5,09,20,593.00	-	-	5,09,20,593	25,46,030	1,81,86,083	32,23,274	-	2,14,09,357	2,95,11,236	3,27,34,510
5 LIBRARY BOOKS	9.50%	46,47,17,195.00	-		46,47,17,195	2,32,35,860	44,13,57,119	-	-	44,13,57,119	2,33,60,076	2,33,60,076
TOTAL(B)		67,20,17,051	8,06,562	-	67,28,23,613	3,36,41,182	60,75,86,815	32,45,693	-	61,08,32,508	6,19,91,105	6,44,30,236
TOTAL OF CURRENT YEAR (A+B)		**2,01,83,48,490**	**71,39,319**	**-**	**2,02,54,87,809**	**17,52,97,161**	**1,31,63,59,702**	**5,42,45,400**	**-**	**1,37,06,05,102**	**65,48,82,707**	**70,19,88,788**
PREVIOUS YEAR		**1,94,23,12,898**	**7,60,60,191**	**24,598**	**2,01,83,48,491**	**16,93,30,411**	**1,26,15,71,237**	**5,47,90,802**	**2,337**	**1,31,63,59,702**	**70,19,88,788**	**68,07,41,660**

GRC & Associates * Chartered Accountants * Bhubaneswar

कनिष्ठ लेखा अधिकारी/JUNIOR ACCOUNTS OFFICER
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भुवनेश्वर/BHUBANESWAR

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भुवनेश्वर/BHUBANESWAR

निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
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INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

SCHEDULE 7 -CURRENT LIABILITIES AND PROVISIONS:

(Amount in Rupees)

Particulars	Current Year (2021-22)		Previous Year (2020-21)	
A CURRENT LIABILITIES				
1 Statutory Liabilities:		1,19,758		6,43,694
Professional Tax Payable	0		200	
TDS Salary Payable	0		5,52,690	
TDS Non-Salary Payable	0		45,493	
GST Recovery Payable	89,776		45,161	
GSLI Premium Payable	0		150	
NPS Recovery Payable	29,982		0	
2 Other Liabilities:		3,53,20,125		2,61,98,600
Earnest money Deposit	68,000		11,53,420	
Caution money from Scholars	15,400		15,000	
GSLI Claim Payable	-		41,707	
Project Grant Payable	-		8,29,240	
Provision for Expenses	2,08,81,316		2,31,36,977	
Payable to NALCO Project	49,875			
Gratuity Payable	3,82,603		4,03,475	
Security Deposit - contractors	4,91,421		6,18,781	
Transferable Receipt	10,400		-	
Unspent Grant	1,32,22,000		-	
Incometax Payable	1,99,110		-	
TOTAL(A)		**3,54,39,883**		**2,68,42,294**
B PROVISIONS		15,59,96,029		13,66,16,510
1 Gratuity	7,75,37,741		6,77,75,396	
2 Accumulated Leave Encashment	7,84,58,288		6,88,41,114	
3 Others (Specify)	0		0	
TOTAL(B)		**15,59,96,029**		**13,66,16,510**
TOTAL(A+B)		**19,14,35,912**		**16,34,58,804**

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INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2022

SCHEDULE 11-CURRENT ASSETS, LOANS, ADVANCES ETC.

(Amount in Rupees)

Particulars	Current Year (2021-22)		Previous Year (2020-21)	
A CURRENT ASSETS:				
1 Inventories:		17,75,466		22,89,707
a) Electrical Fittings Stock	10,47,102		13,65,212	
b) Office Stationery	58,804		1,35,998	
c) Computer Stationery	2,03,112		3,00,544	
d) Cleaning Material Stock	-		25,323	
e) Diesel Stock	1,29,917		1,08,752	
f) Carpentry Material Stock	78,595		1,04,570	
g) Workshop Spares	1,77,268		1,82,986	
h) PH Material Stock	80,668		66,322	
2 Cash balances in hand (including cheques/ drafts and imprest)				
3 Bank Balances:		3,53,26,657		5,87,81,442
a) With Scheduled Banks:				
i) In current accounts SBI	26,39,770		1,69,11,601	
b) Savings accounts				
i) IOB CS Pur (SB-10917)	13,09,841		3,88,951	
ii) IOB CS Pur (SB-16916)	87,66,526		1,73,24,514	
iii) UBI CS Pur (SB-316)	-		6,84,944	
iv) UBI CS Pur (SB-14746)	-		23,709	
v) IOP Corpus Fund (SB-19339)	14,70,310		6,02,095	
vi) Project Bank Account (Sch.3)	2,11,40,209		2,28,45,629.16	
TOTAL(A)		**3,71,02,123**		**6,10,71,149**
B LOANS, ADVANCES AND OTHER ASSETS				
1 Loans (Interest bearing):		1,21,150		65,562
a) Computer Advance	1,21,150		65,562	
2 Interest Accrued but not due on Loans		17,053		33,221
a) Motor Car Advance	-		-	
b) House Buildings Advance	16,135		28,243	
c) Computer Advance	918		4,978	
3 Loans (Non-Interest bearing):		1,87,295		4,12,714
a) Staff Advance	1,65,080		10,714	
b) Festival Advance	-		3,36,000	
c) Travel Advance	22,215		66,000	
4 Advances and other amounts recoverable in cash or in kind or for value to be received:		27,87,521		26,47,870
a) On Capital Account				
b) Prepayments	-		-	
c) TDS (IT) Receivable	49,875		-	
d) Receivable from NALCO proect	89,776		-	
e) Security deposit With CESCO	26,21,944		26,21,944	
f) Franking machine deposit	2,976		2,976	
g) Security Deposit with BSNL	2,000		2,000	
h) Security Deposit for GAS	20,950		20,950	
i) STDR against LC	-		-	
TOTAL(B)		**31,13,019**		**31,59,367**
TOTAL(A+B)		**4,02,15,142**		**6,42,30,516**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2022

SCHEDULE 13 -GRANTS/ SUBSIDIES

(Amount in Rupees)

Particulars	Current Year (2021-22)		Previous Year (2020-21)	
1 DAE - Government of India		31,31,00,000		26,66,00,000
a) Non-Plan (Salary)	22,51,00,000		17,69,00,000	
b) Non-Plan (General)	8,80,00,000		8,97,00,000	
2 Government Of Orissa (Non-Plan Revenue)		-		-
TOTAL		**31,31,00,000**		**26,66,00,000**

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SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2022

SCHEDULE 17 - INTEREST EARNED

(Amount in Rupees)

Particulars	Current Year (2021-22)		Previous Year (2020-21)	
1 On Term Deposits:		1,97,784		-
a) With Scheduled Banks				
b) Others (LC & Security Deposit)	1,97,784		-	
2 On Savings Accounts:		-		-
a) With Scheduled Banks				
3 On Loans:		20,685		16,279
a) Computer Advance	20,685		16,279	
b) Motor Car Advance	-		-	
c) Pending Advance	-		-	
TOTAL		**2,18,469**		**16,279**

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SCHEDULE 18- 0THER INCOME

(Amount in Rupees)

Particulars	Current Year (2021-22)		Previous Year (2020-21)	
Other Income				
1 Miscellaneous Income		324		9,026
a) Project Overhead	-		-	
b) I-Card Charge			66	
c) RTI Fee	20		10	
d) Auditorium Charges	-		-	
e) Miscellaneous Income	304		8,950	
2 Sale of Tender paper		-		11,000
3 Rent				
a) Bank Rent	3,60,000	6,66,912	3,60,000	13,30,123
b) Guest House Rent	1,73,680		1,26,370	
c) Hostel Room Rent	1,33,232		8,43,753	
TOTAL		**6,67,236**		**13,50,149**

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SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2022

SCHEDULE 20 - ESTABLISHMENT EXPENSES

(Amount in Rupees)

Particulars	Current Year (2021-22)		Previous Year (2020-21)	
1 Salaries and Wages		16,09,98,910		14,42,92,679
a) Staff Salary	13,10,56,414		11,80,64,615	
b) NPS Contribution	61,00,771		53,08,199	
c) Honorarium	9,78,401		2,87,096	
d) Fellowship	2,23,19,949		2,03,97,769	
e) Remuneration to Medical Officer	5,43,375		2,35,000	
2 Allowances and Bonus		11,24,303		1,11,83,284
a) PRIS	15,240		89,14,534	
b) Update Allowance	8,09,063		22,62,868	
c) Overtime Allowance	-		5,882	
d) Uniform Allowance	3,00,000			
3 Staff Welfare Expenses		30,55,919		47,13,584
a) Reimbursement of Medical Expenses	9,25,833		30,47,588	
b) Canteen Expense	3,01,999		5,590	
c) Recreation & Welfare Expenses	3,67,705		89,411	
d) Children Education Allowance	14,51,048		15,66,000	
e) Medical Aid Centre Expenses	9,334		4,995	
4 Retirement and Terminal Benefits		8,30,72,385		6,25,03,807
a) Leave salary	1,54,05,495		54,28,231	
b) Pension	4,98,45,433		4,87,74,816	
c) Gratuity	1,78,21,457		83,00,760	
5 Others		18,46,764		14,14,737
a) Contigency Grant to Scholars	18,46,764		14,14,737	
TOTAL		**25,00,98,281**		**22,41,08,091**

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INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2022

SCHEDULE 21 -OTHER ADMINISTRATIVE EXPENSES ETC.

(Amount in Rupees)

Particulars	Current Year (2021-22)		Previous Year (2020-21)	
1 Repair & Maintenance		2,46,39,010		2,33,19,898
a) Civil	85,59,770		64,91,706	
b) Vehicle	2,61,148		1,84,018	
c) Library	6,75,283		7,76,131	
d) Workshop	5,718		1,81,239	
e) Furniture	43,226		-	
f) Electrical	8,69,780		5,74,826	
g) AC Plant	31,70,286		51,58,714	
h) Computer	43,35,257		49,84,795	
i) Laboratory	62,93,219		44,79,486	
j) Garden	1,53,731		93,822	
k) Telephone	74,670		70,328	
l) Office Equipment	1,96,922		3,24,833	
2 Electricity and power		2,27,17,545		2,08,60,455
3 Water charges		3,28,942		3,98,753
4 Conference & Symposia		82,305		1,169
5 Science Outreach Activities		3,11,260		6,163
6 Postage & Telegram		66,504		65,426
7 Telephone & Telex		5,67,592		5,19,799
8 Printing and Stationery		6,93,206		6,81,621
9 Travelling Expenses		8,86,642		21,81,086
a) Conference TA	15,033		1,21,458	
b) Foreign Travel	-		-	
c) Visiting scientist TA	1,00,354		1,00,215	
d) Domestic Travel	6,60,502		3,94,972	
e) Leave Travel concession	90,964		15,64,441	
f) Hire Charge	19,789		-	
10 Auditors Remuneration		59,000		1,18,000
11 Entertainment Expenses		2,80,827		86,442
12 Security Charges		59,02,069		59,75,185
13 Professional Charges		4,14,600		89,550
14 Project Revenue Expenses		22,80,106		5,67,593
a) ALICE Utilisation and CBM Participation	-		1,40,152	
b) Development of Computing and Network Facilities	-		88,115	
c) Investigating Spin Structure	8,15,607		-	
d) Vigyan Prativa	14,64,499		3,39,326	
15 Advertisement and Publicity		2,02,754		6,07,342
16 AKRUTI Expenditure		73,719		-
17 Books & Journal		3,45,15,045		3,56,56,551
a) Books	-		-	
b) Online Journal Subscription	3,45,15,045		3,56,56,551	
18 Lease Rent	1,909	1,909	3,676	3,676
19 Priorperiod Expenses	86,676	86,676		
20 Interest on Income Tax	1,12,434	1,12,434		
21 Others		6,57,058		1,73,852
a) Miscellaneous Expenses	6,57,058		73,416	
b) JEST Expenses	-		78,175	
c) Writing off books	-		22,261	
TOTAL		**9,48,79,204**		**9,13,12,562**

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SCHEDULES FORMING PART OF THE ACCOUNTS

FOR THE YEAR ENDED ON 31.03.2022

SCHEDULE 24 - SIGNIFICANT ACCOUNTING POLICIES

1. **ACCOUNTING CONVENTION**

The financial statements have been prepared under accrual basis under historical cost convention with Generally Accepted Accounting Principles in India except for Government Grants.

2 **PROPERTY,PLANT & EQUIPMENTS**

2.1 Freehold: Property, Plant & Equipment are stated at Historical cost less accumulated Depreciation. The cost of acquisition includes the cost of Carriage Inward, duties & taxes and other incidental direct expenses incurred in relation to such particular fixed assets.

2.2 Leasehold: Out of acquired leasehold land of Ac. 56.130 dec., the institute is in possession of title of land of Ac.6.130 dec. . The Lease rent has been paid on A6.130 dec land upto 31.03.2022. Rest of the land is in the name of Higher Education Department, Govt. of Odisha, alienated in favour of the Institute and hence for this part, no rent is due to the State Government.

3. **INVESTMENT**

Noncurrent Investments are carried individually at cost less Provision for diminution. Current Investments are carried at lower of Cost of fair value.

However, the Institute has no long-term Investment of any nature. Moreover, there are short-term investments in shape of STDR with bank.

4. **VALUATION OF INVENTORIES**

Stock of Office Stationery, Computer Stationery, Cleaning Material Stock, Hardware and Electrical items etc. are valued at cost.

5. BANK BALANCE

Earmarked/ Endowment Fund (As per Sch-3) Bank balances of ₹ 2.11 Crore shown under the total Bank balances.

6. **DEPRECIATION**

6.1 Depreciation is provided on straight-line method at the rates specified in the Company Act, 1956. However, the amendment of 2013 has not been taken into account. Depreciation has been charged on those assets whose WDV are exceeding the residual value of 5% of Gross Block as per the fixed assets schedule.

6.2 Assets costing ₹ 5000/- or less are fully provided.

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7. **GOVERNMENT GRANTS / SUBSIDIES**

The grants are accounted for on realisation basis.

7.1. Plan grants to be utilised for capital expenditure is treated as Capital Fund.

7.2. Non-Plan grants to be utilised for revenue expenditure has been taken into Income & Expenditure A/c.

7.3. The Grants received, unutilized at the yearend has been considered as current Liability.

8. **FOREIGN CURRENCY TRANSACTIONS**

Transactions involving foreign currency are accounted at the exchange rate prevailing on the date of the transactions.

9. **RETIREMENT BENEFITS**

9.1 Liability in respect of Gratuity on retirement payable as on 31.03.2022 has been provided in accounts on actual basis. Provision for liability towards accumulated leave encashment benefit to the employees as on 31.03.2022 has been provided for in accounts on actual valuation.

9.2 Provision for liability payable towards Pension to the employees has been provided in the Accounts.

9.3 No Pension fund has been created by the Institute.

9.4 Contribution to newly defined pension scheme has been made regularly by the Institute for those employees who have joined the Institute after 01-01-2004.

9.5 The Institute has its own Provident Fund Trust which manages the Provident Fund of the employees who have joined the Institute on or before 31.12.2003. The Accounts of the Trust for the year ending 31.03.2022 has been audited by a firm of Chartered Accountants.

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SCHEDULES FORMING PART OF THE ACCOUNTS

FOR THE YEAR ENDED ON 31.03.2022

SCHEDULE 25 – CONTIGENT LIABILITIES AND NOTES ON ACCOUNTS

1. CONTIGENT LIABILITIES

1.1.	Bank Guarantee given by / on behalf of the Institute	NIL
1.2.	Bills discounted with Bank	NIL
1.3.	Letter of Credit	Nill
1.4.	Disputed demand in respect of	
	Income Tax	NIL
	Sales Tax/GST (IDS)	NIL
	Municipal Taxes	NIL
1.5.	In respect of claims from parties for non-execution of orders	NIL

2. NOTES ON ACCOUNTS

2.1. **CURRENT ASSETS. LOANS AND ADVANCES**

The current assets, loans and advances have a value on realization in the ordinary course of business, equal at least to the aggregate amount shown in the Balance Sheet.

2.2. **CURRENT LIABILITIES & PROVISIONS**

All known liabilities have been provided in the accounts of the Institute.

2.3. **TAXATION**

The Institute is a research-oriented organization founded by Government of India, Department of Atomic Energy jointly with Government of Odisha. The income of the Institute is exempted under Income-tax Act 1961 and hence no provision for Income tax has been made during the year.

2.4. External Grants from DST & other funding agencies for specific projects/fellowship have been taken into account in the year under Earmarked Fund.

2.5. Figures in the Balance Sheet and Income & Expenditure Account have been rounded off to nearest rupee.

2.6. Previous year's comparative figures have been regrouped/ rearranged, wherever necessary. Figures in the brackets indicate (-ve).

2.7. Income recognition on interest on staff Loan is accounted after the repayment of principal as per practice adopted. Interest on saving bank is accounted on receipt basis.

2.8. Schedule 1 to 25 are annexed to and form an integral part of the Balance Sheet as at 31.03.2022 and Income & Expenditure Account for the year ended on that date.

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3 FOREIGN CURRENCY TRANSACTIONS

Value of Imports calculated on C.I.F/Ex-works & FOB basis	31.03.2022 (₹)	31.03.2021 (₹)
a) Purchase of Lab. Equipment	5,99,70,646	16,24,500
b) Stores, Spares and Consumables	5,99,833	1,54,074
c) Journal subscription	2,79,52,280	3,21,87,370
Expenditure in foreign currency		
a) Travel	Nil	Nil
b) Other expenditure (Honorarium)	1,24,466	Nil
Earnings		
Value of Exports on FOB basis	Nil	Nil

4 Remuneration to Auditors

As Auditors	50,000	50,000

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GRC & Associates Bhubaneswar Chartered Accountants

ACTION TAKEN REPORT ON THE COMMENTS OF STATUTORY AUDITORS ON THE ANNUAL ACCOUNTS OF INSTITUTE OF PHYSICS, BHUBANESWAR FOR THE FINANCIAL YEAR 2021-22

Sl. No.	AUDITOR'S OBSERVATION	INSTITUTE'S REPLY
Qualified opinion		
Basis of qualification		
1	a) The Society has not followed IAS 10 for accounting of Fixed Assets and AS 6 for provision of depreciation. The society has not maintained fixed assets register to verify the individual asset residual value. Depreciation has been charged on gross block at the end of the year on SLM method irrespective of the fact that individual old assets may have been depreciated in full. The depreciation on assets purchased during the year was also charged for the whole year instead of proportionate basis from date to use.	Noted for corrective measures. The Institute has engaged M/s. Laldash& Co., CAs vide W.O. No. 793 dt.25.06.2018 for preparation of Asset Register from 2011-12 onwards and they have submitted their report year wise up to 2020-21. The current year Assets Register has been prepared by the Institute.
	b) The Fixed Assets of the Society were not physically verified in full during the year under audit.	The institute is doing the physical verification of Fixed Assets on yearly basis. The assignment of physical verification is in full swing by M/s. Laldash & Co., CAs. along with the internal team to be completed soon
	c) None of the Fixed Assets of the Society were tested for impairment in accordance with AS 28 and no provision has been made for impairment if any.	Point has been noted for future compliance.
2	IAS 12 on accounting of Government grants has not been followed. The grants have been recognized on realization basis. Capital grants have been recognized as capital fund and shown as Liability.	The Institute has been receiving full grant from DAE (Govt. of India) under GIA (General) and GIA(Creation of Capital Assets) which is treated as Capital Fund as per the provision of Accounting Standard 12.
3	The Capital Fund of the Institute is decreased to the tune of Rs132.22 lakhs to due recognition of unutilised Government grant as current liabilities at the end of the year.	No comments
Matter of emphasis		
1	Balances of advances and liabilities to/from third parties are subjects to confirmation.	Point has been noted for future compliance.

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