Annual Report
&
Audited Statement of Accounts
2020-21

Institute of Physics
Bhubaneswar

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Bhubaneswar

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Contents

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 experimental 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 2020-21

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-751005	:	Member
3.	Prof. Pinaki Majumdar, Director, Harish-Chandra Research Institute Chhatnag Road, Jhunsi, Allahabad-211019.	:	Member
4.	Prof. Gautam Bhattacharyya, Director, Saha Institute of Nuclear Physics Sector-1, Block-A/F, Bidhan Nagar, Kolkata-700064.	:	Member
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6.	Dr. Shashank Chaturvedi, Director, Institute for Plasma Research Bhat Village, Near Indira Bridge, Gandhinagar-382428.	:	Member
7.	Shri A. R. Sule, IDAS, Joint Secretary (R&D) (until 17.05.2020) Deptt. Of Atomic Energy Anushakti Bhavan, C.S.M Marg, Mumbai-400001	:	Member
8.	Smt. Sushma Taishete, Joint Secretary (R&D) (Since 18.05.2020) 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 Santosh Kumar Sarangi, Principal Secretary to Govt. of Odisha Science and Technology Department. Odisha Secretariat Bhubaneswar-751001.	:	Member
11.	Prof. Surya Narayan Nayak, Department of Physics Sambalpur University, Jyoti Vihar, Burla, Sambalpur-768019.	:	Member
12.	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,
Institute of Physics, Bhubaneswar - 751005

From the Director's Desk

I am glad to present before you the "Annual Report & Audited Statement of Accounts" of the Institute of Physics (IoP), Bhubaneswar, for the fiscal year 2020-21. This Annual Report provides a summary of our academic and research efforts and achievements. IoP, Bhubaneswar is a self-contained institute under the Department of Atomic Energy (DAE), Government of India. It is one of India's leading research institutes dedicated to high-quality cutting-edge research in experimental and theoretical physics, namely, theoretical high energy physics, theoretical condensed matter physics, theoretical nuclear physics, quantum information, experimental condensed matter physics, and experimental high energy nuclear physics.

This year, IOP members have published 88+ papers in high-quality international peer-reviewed journals, demonstrating the outstanding level of research. Members of the Institute have also engaged with scientists from several national and international institutes virtually and published several research papers. One of the HEP group members, Prof. S. K. Agarwalla has received the prestigious "Swarnajayanti Fellowship 2019-20" from Department of Science and Technology (DST), India and "N. S. Satya Murthy Award 2020" from the Indian Physics Association (IPA). Prof. D. Chaudhuri has received SERB-MATRICS project grant and is selected as an Associate of ICTS-TIFR, Bangalore. Prof. K. Ghosh has been elected as Associate of IASc, Bangalore. Prof. M. Mitra has received the Indo-French bilateral collaborative research grant, funded by the Indo-French Centre for the Promotion of Advanced Research (IFCPAR/CEFIPRA).

Despite the pandemic impact, 40+ seminars, colloquia, and workshops were conducted online. The Institute also conducted outreach programs for communicating Science and scientific temper to school and college students, teachers, and the public. Our members enthusiastically celebrated National Science Day and open house days/discussions by delivering popular scientific talks. Activities like night sky viewing with telescopes on the occasion of the Jupiter-Saturn great conjunction were held for IOP members and their families, with strict following of Covid-safety norms. The Institute has also observed the 46th Foundation Day on 4th September 2020, in which Dr. Rajeev Swain from the Institute of Life Sciences (ILS), Bhubaneswar gave a talk on a timely topic, "COVID-19 pandemic: How it started and how it may end".

Finally, I would like to express my sincere appreciation for the support and encouragement that we have received from all the faculty members, research scholars, staff members, and well-wishers of the IOP community, including the Governing Council (GC) members. I would also like to acknowledge the efforts of the members of the Committee who have worked very hard to bring out this Annual Report.

Professor Karuna Kar Nanda
Director, IOP

Contribution of Institute of Physics (IOP) towards DAE Vision

Brief Summary of Annual Report 2020-2021

Institute of Physics, Bhubaneswar is a premier research institute of the country, engaged in research in the frontier areas of theoretical and experimental condensed matter physics, theoretical high energy physics, theoretical nuclear physics, ultrta-relativistics heavy-ion collisions, astro-particle physics and cosmology, quantum information, experimental high-energy nuclear and particle physics and interdisciplinary areas such as quantum computation, biological physics, complex systems, nano-science and materials science.

The Institute is actively involved in the International Collaborations with CERN (Switzerland), BNL (USA), ANL (USA), GSI (Germany), Max Planck Institute (Germany), and other laboratories abroad and also has participated in various research activities related to India-based Neutrino observatory. It has many states-of-the-art experimental facilities like, 3MV pelletron particle accelerator, electron cyclotron resonance-based accelerator, high-resolution transmission electron microscope, molecular beam epitaxy system, pulsed LASER deposition system, Raman spectrometer, photoemission spectrometer, etc. The Institute has the distinction of having a very successful doctoral program and has produced a large number of highly trained and qualified scientists. By now, more than seventy scholars who have done their Ph.D. at the Institute are occupying prestigious faculty/scientist positions in almost all the leading research Institutes, such as IISc, IITs, NITs, IISERs, NISER, Central and State Universities in the country. The Institute has strong outreach programm targeted at students of Schools, Colleges, and Universities for the popularization of science as well as DAE's programmes related to Atomic Energy.

The condensed matter theory group at IOP is actively involved in pursuing research with the main focus on understanding the organization of bacterial chromosome, active matter, fluctuation theorem, topological aspects of quantum condensed matter systems, quantum transport in Dirac/Weyl materials, quantum magnetism, and the interplay of strong correlation and topology in artificial lattice systems.

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 proposed CBM experiment at FAIR, GSI (Germany). The groups contribute to the studies of the properties of the observed Higgs boson and searches for beyond the Standard Model particles in proton-proton collision events at LHC as well as the studies of Quark-Gluon plasma, a state of matter in the early universe, which are recreated in heavy-ion collisions. Furthermore, the groups contribute to the R&D of state-of-the-art detectors for future experiments.

In experimental condensed matter physics, major activities included studies on accelerator-based materials science, surface and interface physics, advanced functional materials, and nano systems. The Ion Beam Laboratory houses the NEC 3 MV tandem Pelletron Accelerator, 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. Different users (both internal and external) and research scholars across the country are using this facility for their research. Other important research activities include studies on solar energy photovoltaics, self-organized pattern formation on semiconductor surfaces, and their nanoscale functionalization by growing metallic nanostructures and magnetic thin films on patterned substrates to study anisotropic plasmonic and magnetic properties, and tunable metal oxide-based resistive switching devices for neuromorphic applications using energetic ion beams, quantum matter heterostructures, strongly correlated electron system, quantum transport in spin-orbit coupled systems, interfacial exchange bias phenomena, Raman spectroscopy, and the physics of 2D chalcogenide based materials and devices.

Highlights of academic/research activities of IOP:

The admission process of the doctoral students through online mode for both the written test and the interaction sessions is completed. Fifteen students have been selected, and the offer letter for admission is sent to them for joining in the 1st /2nd week of January 2021. IOP has also selected 9 postdocs for this year and they are now joining the institute. The doctoral students who left for their native places due to COVID, have been directed to return to the institute in a phased manner following the COVID guidelines of the State Government. One visiting Scientist has joined the Institute. Besides, one DST-inspire faculty and one visiting scientist will be joining the institute very soon. The appointment process of a faculty in the CMS activity of the institute is in progress.

IoP faculty members have published about 88 research papers in international peer-reviewed journals in the fields of Condensed Matter Physics and Materials Science, High Energy Physics, Nuclear Physics, and Quantum Computation. Some of these high impact journals are Physical Review Letters (IF: 9.16), Physics Review A, B, C, D & E (IF: 2.53 to 5.3), Advanced Functional Materials (IF: 18.81), Nature Communications (IF: 14.92), Journal of Physical Chemistry Letters (IF: 6.71), Journal of High Energy Physics (IF: 5.875), Journal of Materials Chemistry C (IF: 7.059), Solar Energy (IF: 4.608), and Monthly Notices of the Royal Astronomical Society (IF: 5.356). Prof. D. Samal has co-authored a topical review on "Electronic and topological properties of group-10 transition metal dichalcogenides" in the Journal of Physics: Condensed Matter. Besides, two IOP faculty members, Prof. P. K. Sahu, and Prof. Arun Nayak have carried out research work under the international ALICE and CMS mega-science collaboration programme and co-authored more than 50 research publications in high impact journals during this period.

Faculty members from IoP have received national/international recognition/awards/ appointment/research grants. Some of these include: Prof. Sanjib Kumar Agarwalla has received the prestigious "**Swarnajayanti Fellowship 2019-20**" from DST, Govt. of India to unravel the landscape of Beyond the Standard Model (BSM) Physics at Neutrino Experiments, and "N. S. Satya Murthy Award 2020" from the Indian Physics Association (IPA) in recognition of his insightful research in neutrino oscillation phenomenology, exploring the measurements of neutrino mixing parameters and searches for possible signatures of physics beyond the Standard Model. Prof. Sanjib Kumar Agarwalla has been nominated by DST, to feature in the Coffee Table Book titled "**50 Scientists under 50**" as a part of the DST Golden Jubilee Celebrations. Prof. Agarwalla also received a research grant of Rs. 80 Lakhs from the Science and Engineering Research Board (SERB) to pursue research in the field of neutrino physics for the next five years. Prof. Aruna K. Nayak has been appointed as the convener (Level-2) under the CMS Trigger Coordination. Prof. Manimala Mitra has received the Indo-French bi-lateral research grant. Prof. Sanjib Kumar Agarwalla has received a **research grant from the SERB-DST**. Prof. D. Chaudhuri has received SERB-MATRICS project grant and is selected as an Associate of ICTS-TIFR, Bangalore. Prof. Kirtiman Ghosh has been elected as Associate of IASc, Bangalore. Prof. Shikha Varma is selected as an Editorial Board Member in Journal of Physics: Condensed Matter, Published by IOP Publishing, UK.

Faculty members from IoP have delivered about 40 invited online talks at various national/ international Seminars / Colloquia/Conferences. Some of the faculty members of IOP are also involved in organizing two international conferences in high energy physics. An online conference on "Emerging Trends in Quantum matters, Statistical and Biological Physics" was organised at IoP during 23-24 November 2020. A lecture series (webinar) on "From Tiny Atoms to Solid to Cosmos: The Quantum Aspects" was organized by the Department of Physics, CET, Bhubaneswar in collaboration with the IOP, Bhubaneswar during 01-05, 2020.

Prof. Ajit M. Srivastava has delivered five popular talks on the universe, elementary particles, and dark energy including a commentary on World Asteroid Day in the English World Service of All India Radio.

The DAE funded Spin Structure Project has been pushed ahead by placing the purchase order of two major equipment costing Rs 6.45 cr, and opening one LC for Rs 2.10 cr. The tendering process for other items costing around Rs 1.20 cr is in progress.

Prof. Arun M. Jayannavar, an eminent scientist of IOP who was an extension for the 2nd term, superannuated on 31/07/2020. The institute is proud of his outstanding scientific contributions in theoretical condensed matter physics.

The term of service of Prof. Ajit M. Srivastava has been extended from 60 to 62 years w.e.f. 01/09/2020 with due approval of the GC.

Highlights of other activities:

Until now, there were 19 cases of COVID-19 positive in the IOP campus, and the same were handled effectively and efficiently with the help of the local authorities. Post COVID scenarios are also tackled properly.

The Hindi Pakhwada was observed through a lecture series on current events, such as COVID-its relevance and treatment, the current scenarios of office operation in the COVID situation, etc. IOP organized two online conferences in association with four other institutes in Bhubaneswar viz., NISER, ILS, CIFA, and AIIMS. IOP also celebrated the Annual Day of the institute on 4th September 2020 through online mode lectures. Besides, Sadbhavana Day and Constitution Day are the two other events of prominence which were organized during this period.

IOP and NISER have been jointly implementing the Vigyan Pratibha Project in Odisha as the Regional Center for the project.

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, an important academic program designed to train the M.Sc. students to carry out research activities. This programme is aimed at imparting 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 interested in pursuing a PhD in physics. The final selection of a student is based on the result of a written test and an interview conducted at the Institute. This year the Pre-doctoral course began in January 2021. 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 PhD degree awarded by Homi Bhabha National Institute (HBNI).

The Institute has instituted Lalit Kumar Panda Memorial Endowment Fellowship (L. K. Panda Memorial Fellowship) to recognise 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 Rameswar Sahu.

A total of 386 students were called for written test and interview for admission to the pre-doctoral course in October, 2020. This includes JEST qualifiers, UGC-CSIR qualifiers and valid GATE score holders. Following students enrolled on the doctoral course work program for the year 2020-2021:

1. Mr. Suman Roy
2. Mr. Raju Mandal
3. Mr. Sharmistha Chattopadhyay
4. Mr. Manish Patel
5. Mr. Aswin Kumar Burma
6. Mr. Pujalin Biswal
7. Mr. Kamalesh Bera

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

Semester – I

Advanced Quantum Mechanics	:	Dr. Kirtiman Ghosh
Advanced Statistical Mechanics	:	Dr. Debasish Chaudhuri
Quantum Field Theory – I	:	Dr. Debottam Das
Advanced Experimental Techniques	:	Dr. Satyaprakash Sahoo
Experimental Physics Lab	:	Dr. Dinesh Topwal

Semester – II

Numerical Methods Mathematical Methods & Research Methodology	:	Dr. Goutam Tripathy
Advanced Condensed Matter Physics	:	Dr. Arijit Saha
Quantum Field Theory – II	:	Prof. Pankaj Agrawal
High Energy Physics	:	Dr. Manimala Mitra
Special Topics in Statistical Physics (Critical Phenomena)	:	Prof. Sudipta Mukherji
Special topics in Condensed Matter Physics Magnetism & Correlation Effect's in Solids	:	Prof. B. R. Sekhar, Dr. Debakanta Samal

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

1.2 DOCTORAL PROGRAM

Presently Institute has forty eight 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. Vijigiri Vikas

Advisor: Dr. Saptarshi Mandal

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

2. Mr. Debasish Saha

Advisor: Prof. Pankaj Agrawal

Thesis Title: Production of Higgs boson in association with another two bosons at the hadron colliders.

3. Mr. Ashis Manna

Advisor : Prof. Shikha Varma

Thesis Title : Growth of TiO_2, ZnO nanostructured films for investigation of resistive switching, photo-absorbance properties, glucose sensing and structural phase transition.

4. Mr. Ganesh C. Paul

Advisor : Dr. Arijit Saha

Thesis Title: Transport and magnetic exchange properties of spin-orbit coupled, anisotropic Dirac materials and Majorana nanowires.

5. Mr. Amit Kumar

Advisor : Dr. Debasish Chaudhuri

Thesis Title : Polymeric models for chromosome Organization: Impact of cross-linkers, crowders and confinement.

1.4 Conferences / Workshops organised by IOP

Emerging trends in Quantum matters, Statistical and Biological Physics: 23-24 Nov 2020

(A web conference to felicitate Prof Arun M Jayannavar, organised by IOP, Bhubaneswar)

https://www.iopb.res.in/felicitate2020/felicitate-conference.pdf

A felicitation conference has been organised to commemorate the superannuation of Prof Arun M Jayannavar. Prof Jayannavar has served the Institute as distinguished faculty for around thirty years. Over this long journey, he has nurtured many young talents and helped them established as a successful scientist or academician or experts in their respective workplaces. Besides this invaluable contribution, he has brought in many glories to the Institute, being awarded the ICTP award in 1996 and the Shanti Swarup Bhatnagar award in 1998, to name a few. Prof Jayannavar also served as a full-time director. The condensed matter group of IOP had unanimously decided to organise a felicitation conference such that we all can have a glimpse of his illustrative career before us, further motivating the IOP as a whole to maintain its high standard.

Due to the Covid-19 pandemic situation, the conference has been held online. The conference has been a great success with twenty invited talks. For detail information about the speakers and the title of the talks, one may visit www.iopb.res.in/felicitate2020/schedule.pdf. It was self-evident that the conference was honored with the presence of many dignified scientists (mainly close associates of Prof Jayannavar) and was celebrated by his past and present collaborators. The then Director Prof. S. M. Yusuf had gracefully inaugurated the conference. The talks were very high scientific substances comprising diverse fields. There were around 50 participants besides the invited speakers. All the participants were provided with a participants certificate as promised. The conference was ended with friendly chats among friends of Prof Jayannavar and the family of Prof Jayannavar that went on indefinitely.

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 2020-21 are in the following.

Prof. A. M. Srivastava and collaborators studied the observable imprint on the pulsar signals due to gravitational wave-induced transient change in the pulsar moment of inertia. They came up with a list of specific pulsars whose future signals will carry imprints of past GW events. Prof. Pankaj Agrawal's research focused on the measurement of Higgs boson self-couplings at the high-energy LHC. They found that double-Higgs production at the 27 TeV high-energy LHC can be used to discriminate different Higgs potential scenarios, while it is necessary to use triple-Higgs production at a future 100 TeV proton-proton collider to determine the shape of the Higgs potential fully. Prof. S. K. Agarwala's research on the impact of Lorentz Invariance Violation on the sensitivity of the Deep Underground Neutrino Experiment (DUNE) found substantial deterioration of the octant discovery potential at the DUNE experiment. Prof. S. K. Agarwala investigated the impact of flavor violating neutral current non-standard interaction (NSI) in the oscillation of atmospheric neutrinos and antineutrinos separately using the 50 kt magnetized ICAL detector at INO. They demonstrated that by adding the hadron energy information along with the muon energy and muon direction in each event, the sensitivity of ICAL to the NSI can be enhanced significantly. Prof. S. Banerjee is working on holography and scattering amplitudes in asymptotically flat space-time. One of Prof. Banerjee's main achievements is the calculation of tree-level MHV graviton scattering amplitudes in general relativity using asymptotic symmetries. Dr. D. Das showed that the Standard Model (SM) extended with a Leptoquark (LQ) and right-handed neutrinos can have interesting new implications for Higgs physics. In particular, they found significant contributions from the quark fusion process, resulting in an enhanced Higgs production rate at the LHC. In an attempt to explain the null results from dark matter (DM) direct detection experiments, Dr. D. Das and collaborators studied the possibility of cancellation among different terms in the DM-nucleon scattering. They showed that such cancellation could lead to a vanishingly small DM direct-detection cross-section. Dr. Manimala Mitra, with her collaborators, focuses on few different neutrino mass models and associated dark matter and collider phenomenologies. Few of them are gauged B-L model to explain dark matter relic density where thermal mass correction of the scalars has been taken into account, Vacuum Stability in Inert Dark Matter Model with Type-III inverse seesaw. Dr. Mitra's other significant works include the discovery prospect of a scalar leptoquark at a future ep collider, same-sign tetra lepton signature, charged Higgs phenomenologies and a novel search

strategy to investigate spin-parity of muon-philic X boson. Dr. K. Ghosh and his students worked on the phenomenological implications of the information lost in decoupling from High-Energy to Low-Energy in the context of the Type-III seesaw model. Dr. Ghosh's group also worked on the phenomenology of minimal and non-minimal Universal Extra Dimension models in the light of LHC data at 13 TeV. Their study clearly shows that mUED parameter space is completely ruled out by the collider searches and dark matter relic density data. Prof. A. K. Nayak used a deep learning approach to search for invisibly decaying Higgs boson produced in vector-boson fusion channel. Prof. Nayak and collaborators studied the advantages of using jet substructure techniques to probe heavy dijet resonances.

(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. Hawking radiation from acoustic black holes in relativistic heavy-ion collisions

Quark gluon plasma in relativistic heavy-ion collisions is the "most inviscid" fluid known. This provides a good example of a quantum fluid,naturally suited to studies of acoustic Hawking radiation. Using Ultra relativistic quantum molecular dynamics} (UrQMD) simulations for relatively low energy collisions, we show that for a short duration, we can have a conformally static acoustic metric with a (conformal) Killing horizon coinciding with the apparent horizon. An asymptotic observer will then see a thermal flux of phonons, constituting the Hawking radiation, coming from the horizon.

Initial fluctuations and power spectrum of flow anisotropies in relativistic heavy-ion collisions: Review article

The evolution of initial state fluctuations in relativistic heavy-ion collisions leave imprints on the power spectrum of flow coefficients, providing 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 probe initial inflationary fluctuations. We review these developments. This acquires special importance with upcoming electron-ion collider which will directly probe initial parton distribution of the nuclei.

Cosmology and astrophysics

Gravitational waves emitted from different sources affect pulsars causing (tiny) transient deformations in their shapes. Some of us have recently shown that the resultant transient change in the pulsar moment of inertia may leave an observable imprint on the pulsar signals as detected on earth, especially at resonance. The pulsars may thus act as remotely stationed Weber gravitational wave detectors. This allows us to revisit the past GW events, (including past supernova events) via pulsars. We give here sample list of specific pulsars whose future signals will carry imprints of past GW events. For example, signal of supernova SN1885 via pulsar B2310+42, should earth some time during year 2022 to 2044, and signal of supernova SN1604 via pulsar J1813-1246 during 1971 to 2052.

(Ajit M. Srivastava)

2. Although the Higgs boson has been discovered, its self-couplings are poorly constrained. This leaves the nature of the Higgs boson undetermined. Motivated by different Higgs potential scenarios other than the Landau-Ginzburg type in the standard model, we systematically organize various new physics scenarios — elementary Higgs, Nambu-Goldstone Higgs, Coleman-Weinberg Higgs, and tadpole-induced Higgs, etc. We find that double-Higgs production at the 27 TeV high-energy LHC can be used to discriminate different Higgs potential scenarios. However, to fully pin down the quartic Higgs coupling and thus the shape of the Higgs potential in various scenarios, we need to investigate the triple-Higgs production process.

$pp \to hhh$ at future colliders.

(Pankaj Agrawal)

3. Atmospheric neutrino experiments can show the "oscillation dip" feature in data, due to their sensitivity over a large L/E range. In experiments that can distinguish between neutrinos and antineutrinos, like INO, oscillation dips can be observed in both these channels separately. We present the dip-identification algorithm employing a data-driven approach – one that uses the asymmetry in the upward-going and downward-going events, binned in the reconstructed L/E of muons – to demonstrate the dip, which would confirm the oscillation hypothesis. We further propose, for the first time, the identification of an "oscillation valley" in the reconstructed (Eμ, cosθμ) plane, feasible for detectors like ICAL having excellent muon energy and direction resolutions. We illustrate how this two-dimensional valley would offer a clear visual representation and test of the L/E dependence, the alignment of the valley quantifying the atmospheric mass-squared difference.

We examine the impact of Lorentz Invariance Violation (LIV) in measuring the octant of θ23 and CP phases in the context of the Deep Underground Neutrino Experiment (DUNE). We consider the CPT-violating LIV parameters involving e - μ (aem) and e - τ (aeτ) flavors, which induce an additional interference term in neutrino and antineutrino appearance probabilities. This new interference term depends on both the standard CP phase δ and the new dynamical CP phase ϕεμ/ϕετ, giving rise to new degeneracies among (θ_{23}, δ, ϕ). Taking one LIV parameter at-a-time and considering a small value of $|\alpha\varepsilon\mu| = |a\varepsilon\tau| = 5 \times 10^{-24}$ GeV, we find that the octant discovery potential of DUNE gets substantially deteriorated for unfavorable combinations of d and ϕεμ/ϕετ.The octant of θ_{23} can be resolved at 3σ if the true value of $\sin^2\theta_{23} \leq 0.42$ or 0.62 for any choices of δ and ϕ. Interestingly, we also observe that when both the LIV parameters aem and aet are present together, they cancel out the impact of each other to a significant extent, allowing DUNE to largely regain its octant resolution capability.

We explore the impact of flavor violating neutral current non-standard interaction (NSI) parameter e_{mt} in the oscillation of atmospheric neutrinos and antineutrinos separately using the 50 kt magnetized ICAL detector at INO. We find that due to non-zero e_{mt}, muon neutrino and antineutrino transition probabilities get modified substantially at higher energies and longer baselines, where vacuum oscillation dominates. We demonstrate for the first time that by adding the hadron energy information along with the muon energy and muon direction in each event, the sensitivity of ICAL to the NSI parameter $\varepsilon_{\mu\tau}$ can be enhanced significantly. The most optimistic bound on e_{mt} that we obtain is $-0.01 < \varepsilon_{\mu\tau} < 0.01$ at 90% C.L. using 500 kt yr exposure and considering Eμ, $\cos_{\mu}$, and E'_{had} as observables in their ranges of [1, 21] GeV, [-1, 1], and [0, 25] GeV, respectively. We discuss for the first time the importance of the charge identification capability of the ICAL detector to have better constraints on $\varepsilon_{\mu\tau}$. We also study the impact of non-zero $\varepsilon_{\mu\tau}$ on mass hierarchy determination and precision measurement of oscillation parameters.

(S. K Agarwalla)

4. My current research is focussed on holography and scattering amplitudes in asymptotically flat space time. In this case the

asymptotic symmetries are infinite dimensional and the S-matrix satisfies the ward identity corresponding to that. This puts strong constraint on the structure of S- matrix involving gravitons and gluons as external lines. One of our main achievements is the calculation of tree level MHV graviton scattering amplitudes in general relativity using the asymptotic symmetries. We have also been able to compute the MHV gluon scattering amplitudes using the infinite asymptotic symmetries. This calculation provides strong evidence for holography in asymptotically flat four dimensional space time.

(S. Banerjee)

5. The Standard Model (SM) when extended with a Leptoquark (LQ) and right handed neutrinos, can have interesting new implications for Higgs physics. We show that the sterile neutrinos can induce a significant boost to the down-type quark Yukawa interactions through a diagonal coupling associated with the quarks and a scalar LQ of electromagnetic charge 1/3. The relative change is much more pronounced in case of the first two generations of quarks as they have vanishingly small Yukawa couplings in the SM. The enhancement in the couplings would also lead to a non-negligible contribution of the quark fusion process to the production of the 125 GeV Higgs scalar in the SM, though the gluon fusion always dominates. However, this may not be true for a general scalar. As an example, we consider a scenario with a SM-gauge-singlet scalar ? where an $O(1)$ coupling between ? and the LQ is allowed. The ?qq Yukawa couplings can only be generated radiatively through a loop of LQ and sterile neutrinos. Here, the quark fusion process can have significant cross section, sp6ecially for a light?. It can even supersede the normally dominant gluon fusion process for a moderate to large value of the LQ mass. This model can be tested/constrained at the high luminosity run of the LHC through a potentially large branching fraction of the scalar to two-jets.

Extensive searches to probe the particle nature of dark matter (DM) have been going on for some decades now but, so far, no conclusive evidence has been found. Among various options, the Weakly Interacting Massive Particles (WIMP) remains one of the prime possibilities as candidates for DM near the TeV scale. Taking a phenomenological view, such null results may be explained for a generic WIMP in a Higgs-portal scenario if we allow the light-quark Yukawa couplings to assume non-Standard Model (non-SM)-like values. This follows from a cancellation among direct-detection terms in the DM-nucleon scattering which can, in turn, lead to a vanishingly small direct-detection cross section. It might also lead to isospin violation in the DM-nucleon scattering. Such non-SM values of light-quark Yukawa couplings may beprobed in the high luminosity run of the LHC.

(Debottam Das)

6. The prime objective of my ongoing research is to understand nature at the fundamental level. The 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 three of the most prominent areas of High Energy Physics, which are Neutrino Physics, Dark Matter, and Beyond the Standard Model Physics (BSM physics).

The recent research works published in between April, 2020- March, 2021, with her students, postdoc and collaborators focus on few different neutrino mass models and associated dark matter and collider phenomenologies. Few of them are gauged B-L model to explain dark matter relic density where thermal mass correction of the scalars have been taken into account, Vacuum Stability in Inert Dark Matter Model with Type-III inverse seesaw. In another work which was authored with my student Abhishek Roy, we 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.

In another significant work with the student Rojalin Padhan, the discovery prospect of a scalar leptoquark at a future ep collider has been thoroughly analysed. It has been shown that a lepton+jet final state from a leptoquark decay has a very good discovery prospect at the ep collider with using only 100 inverse-fb data. In another work, a novel signature- same-sign tetra lepton signature has been analysed. The charged Higgs phenomenologies have also been investigated in detail. Finally, with postdoc Dr. Dibyakrupa Sahoo, a novel search strategy to investigate spin-parity of muon-philic X boson has been implemented.

(M.Mitra)

7. Explaining the tiny neutrino masses and non-zero mixings have been one of the key motivations for going beyond the framework of the Standard Model (SM). We studied the phenomenology of models that generates neutrino masses at a 1-loop level as well as tree level. Usually, loop induced neutrino mass models require some additional symmetry to forbid tree-level seesaw contributions to the Weinberg operator. However, we propose a model in which the additional fields and their gauge quantum numbers are chosen in such a way that the couplings, which give rise to the Weinberg operator at tree-level, are absent and hence, the tree-level contributions to the neutrino masses are forbidden without any additional symmetry. Apart from effortlessly explaining neutrino oscillation data with Yukawa couplings of the order of the SM charged lepton Yukawa couplings, the model can explain the discrepancy between the experimental measurement and the SM prediction of muon magnetic moment and gives rise to exciting signatures at the collider experiments. After fitting the neutrino masses and mixings, we studied the constraints resulting from the upper bound on the absolute neutrino mass scale. We also examined the production, decay, and the resulting collider signatures of these TeV scale fermion/scalars in the context of the LHC experiment.

Type-III Seesaw: Phenomenological Implications of the Information Lost in Decoupling from High-Energy to Low-Energy: The high energy seesaw theory involves 15(9) effective parameters, whereas the low-energy neutrino phenomenology involves 9(7) physical and measurable parameters in 3(2) right-handed neutrino [3RHN(2RHN)] case. A number of parameters get lost in integrating the heavy fields out. The well-known Casas-Ibarra parametrization facilitates encoding the information lost in the decoupling of the heavy fermions in an arbitrary complex orthogonal

matrix (R) with 6(2) real parameters in 3RHN(2RHN) case. We have explored the phenomenological implications of the said matrix in view of lepton flavor violation, displaced decays, and a recent multilepton final states search by the CMS collaboration.

Minimal and non-minimal Universal Extra Dimension models in the light of LHC data at 13 TeV: Universal Extra Dimension (UED) is a well-motivated and well-studied scenario. One of the main motivations is the presence of a dark matter (DM) candidate, namely, the lightest level-1 Kaluza-Klein (KK) particle (LKP), in the particle spectrum of UED. The minimal version of

UED (mUED) scenario is highly predictive with only two parameters, namely, the radius of compactication and cut-off scale to determine the phenomenology. Therefore, stringent constraint results from the WMAP/PLANCK measurement of DM relic density (RD) of the universe. We have studied one UED against the dataset recorded by the ATLAS collaboration. Our study clearly shows that mUED parameter space is completely ruled out by the collider searches and dark matter relic density data. Next, we bring in boundary-localized terms as an extension of mUED, called non-minimal UED. The introduction of such terms alters phenomenology substantially. We have performed a detailed cut-based analysis emulating the ATLAS searches and obtain bounds on the nmUED parameters.

(Kirtiman Ghosh)

8. The Froissart bound on the total cross section is subjected to test against very high energy data. We have found no clear evidence for its violation. The scaling property of differential cross section in the diffraction region is investigated. It exhibits scaling in the ISR, SPS, Tevatron and LHC energy domain which had hitherto remained unexplored. The slope of the diffraction peak is fitted and the data are tested against the rigorous bounds.

Vector boson fusion is a crucial production mechanism to probe nature of the observed Higgs boson or search for new physics. We explore the merit of deep-learning entirely from the low-level calorimeter data in the search for invisibly decaying Higgs. Different neural network architectures, considering both low-level and high-level input variables, are investigated for a detailed comparative analysis. The analysis follows a recent experimental search by CMS for invisible Higgs boson. It is found that sophisticated deep-learning techniques have the capability to improve the bound on invisible branching ratio by a factor of three, utilizing the same amount of data and without relying on any exclusive event reconstruction.

We have employed jet substructure techniques along with multivariate analysis method to improve the sensitivity of the resonance searches, decaying to pair of jets. The techniques improve the separation of jets in terms of their gluonic and quark identities, thereby improving the discrimination of new resonances in the all hadronic final states.

(A. K. Nayak)

2.2. Theoretical Nuclear Physics

The research work of Nuclear Physics (NP) Group at Institute of Physics is mainly to study the properties of the finite nuclei, infinite nuclear matter, neutron stars, Heavy Ion Collisions and ALICE & CBM collaborations.

The finite nuclei properties such as (a) nuclear fission for neutron-rich nuclei (b) nuclear structure and cluster radioactive decay (c) structures of exotic and superheavy nuclei (d) nuclear giant resonances for both stable and unstable nuclei (e) nuclear reaction, and (f) nuclear spectroscopy. The infinite nuclear matter properties related to its equation of state, binding energy, incompressibility, symmetry energy and its different coefficients with/without temperatures in the high/low densities regimes. The neutron star properties such as its equation of state (EOS), mass, radius, tidal deformability, moment of inertia etc. with the addition of different particles/candidates for e.g. hyperons, quarks, dark matter etc. inside it are studied with our recently developed EOSs (G3 and IOPB-I) as well as existing EOSs by using extended relativistic mean-field (E-RMF) formalism. The properties of neutron star in the presence of magnetic field are studied. Recently, the Nuclear Physics Group has explored the gravitational wave properties of the inspiralling binary neutron star with the addition of dark matter. The NP Group has also studied the thermal properties of the proto-neutron stars' neutrino emissivity using our own EOSs with different temperatures. The phase transition and its related phenomena are critically examined in the framework of relativistic mean field (RMF) theory. Apart from neutron stars, we also calculated the surface properties of finite nuclei using Coherent Density Fluctuation Model (CDFM). Here, the RMF densities are folded with the CDFM to numerate the values of nuclear properties for several finite nuclei and neutron star symmetry energy, incompressibility etc.

The study of heavy-ion collisions is mainly between proton-nucleus which are important to study cold nuclear matter, initial conditions, energy loss and parton multiple scattering. Therefore, it is inevitable to understand the effects on the hot de-confined state of hadronic matter formed in relativistic heavy ion collisions. Other than this, the NP Group has analyzed ALICE data to study the $\Lambda(1520)$ resonance. Apart from this, we theoretically work on (i) Application of Nilsson model for deformed nucleus in relativistic heavy ion collisions (ii) Study of strange and non-strange hadron production and ratios in pp and p-Pb collisions at LHC energies (iii) Relativistic interacting Hadron-Resonance Gas model. Recently, we basically worked in the high energy experimental laboratory for ALICE and CBM such as (i) Characterizations of GEM detector prototype (ii) Ion backflow fraction of quadruple GEM detector (iii) Simulation, and (iv) HV Control system for MUCH detector for CBM.

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

1. It is well known that dark matter makes up more than 85% of matter in the Universe. In the compact objects such as neutron stars, there will be possible accretion of dark matter. This is due to the fact that the neutron star has high gravitational potential and immense baryonic density. The dark matter particles interact with baryons which affect the neutron star properties. We study the dark matter effects on the nuclear matter parameters and neutron star observables by characterizing the equation of states of super dense neutron-rich nucleonic matter. The equation of state becomes softer with the addition of dark matter and the softness mainly depends on the percentage of dark matter inside the neutron star. Other observables such as mass, radius, tidal deformability and the moment of inertia are decreases with the increase of dark matter percentage. The curvatures of the neutron stars are calculated with the variation of baryon density. It is found that the radial variation of different curvatures significantly affected by dark matter inside the star. The effects of dark matter on the compactness of the maximum neutron star mass is less as compared to canonical star. The binding energy of the neutron star goes towards positive with the increase of dark matter momentum and makes the system unstable. We find that dark matter produces ~33% more curvature as compared with no dark matter case.

We also explore the in-spiral phase properties of the binary neutron star within the post-Newtonian formalism. The magnitude of different in-spiral properties are almost the same for all assumed forces; however, the in-spiral time duration in the last orbit is different. We find that the binary neutron star with soft equation of state and a high fraction of dark matter sustains more time in their in-spiral phase. We suggest that one should take dark matter inside the neutron star when they model the in-spiral waveforms for the binary neutron star systems.

We put constraints on the secondary component of GW190814 by analyzing the observational data of the event. We observe that the predicted properties are well consistent with GW190814 observational data, suggesting the possibility of a dark matter admixed neutron star if the underlying nuclear equation of state is sufficiently stiff.

We study the thermal effects on the nuclear matter properties with the relativistic mean-field models. The critical temperature for the liquid-gas phase transition in the symmetric are in excellent agreement with previous theoretical and experimental studies. We find that the properties related to the second differential coefficient of the binding energy and free symmetry energy at saturation density are well consistent with empirical/experimental results.

We obtained a density-dependent analytical expression of binding energy per nucleon for different neutron-proton asymmetry of the nuclear matter with a polynomial fitting, which manifests the results of effective-field theory motivated relativistic mean-field model. This expression has the edge over the Brückner energy density functional since it resolves the Coster-Band problem. The values obtained for the neutron pressure, symmetry energy, and its derivative known as the slope parameter lie within a narrow domain whereas there is a large variation in isoscalar incompressibility and

surface incompressibility while moving from light to heavy nuclei.

The investigation of fusion reactions involving light neutron-rich exotic nuclei is of paramount significance to understand nucleosynthesis in astrophysical scenarios. It can also be a heat source to ignite $^{12}C+^{12}C$ reaction and production of x-ray super bursts from accreting neutron stars. Recently, the fusion of neutron-rich ^{20}O with ^{12}C target has been studied. Bass model under predicts the ó-fus and the time-dependent Hartree-Fock model also fails to explain the experimental data. To explicate the same, the investigation of $^{20}O+^{12}C$ reaction at near barrier energies has been made within quantum mechanical fragmentation-based dynamical cluster-decay model (DCM). We have explored the temperature-dependence of different nuclear properties and nuclear symmetry energy within microscopic relativistic mean-field (RMF) theory. We calculcate the microscopic temperature-dependent binding energies (T.B.E.) from RMF theory within DCM and investigate the structure of fragmentation potential for $^{32}Si^*$ formed in $^{20}O+^{12}C$ reaction. The structure and magnitude of fragmentation potential are found to change drastically/notably along with a change in energetically favored/minimized fragments for macroscopic (mac) and microscopic (mic) choices of T.B.E. The σ particles (^4He, ^5He) are favored at lower angular momenta in fragmentation profile for mic T.B.E. case only. A comparison of the relative cross-section of different light-charged particle (LCP) channels toward σ-fus is quite different for both cases of T.B.E. The cross-section of ^2H and ^4He LCP channels is relatively enhanced for mic T.B.E. compared to mac T.B.E.

(S. K. Patra)

2. For spherically symmetric nucleus (Au or Pb), Wood-Saxon (WS) distribution proves to be highly maneuverable and aptly suitable in giving nucleon distribution within a nucleus. We use an alternate approach known as Nilsson model, to explain U+U collisions at 193 GeV of RHIC. We have implemented the formalism in HIJING model to calculate charged particle multiplicity and pseudo-rapidity distributions. The model describes the experimental data more closely than WS/MWS and thus is more suitable to study deformed nucleus within this model formalism.

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. Also, we have presented the isothermal compressibility (kT), specific heat (CV), and speed of sound as a function of μB, T and center of mass energies.

(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 Λ (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. Some hadronic resonance states due to their short lifetimes (~few fm/c) are important to investigate some properties like the time span of the hadronic scattering medium formed in relativistic heavy-ion collisions. We have studied production of Ë in p-p and p-Pb collisions at 7 TeV and 5.02 TeV, respectively.

Gas Electron Multipliers (GEM) detector possess high rate capability and high resolution. A Triple-GEM prototype of area 10 X10 cm^2 was fabricated and characterized using Fe^{55} source. 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. A systematic investigation is also 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 observed ion backflow fraction seems to be very sensitive towards drift field and effective gain of the detector. For Characterization of detector, initiative is taken for doing numerical analysis with Garfield++ simulation package. We simulated 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.

The basic motivation of the HV control system for MUCH detector for CBM is to isolate the high current drawing sections of the GEM detector from the remote location. The design criteria are as follow: the basic objective to disconnect the HV channel from the GEM detector and maintain isolation from the LV section.

(P.K.Sahu)

2. The CMS group at IOP made major contributions to the searches for Higgs production in association with pair of top quarks (ttH) in pp collision data recorded by the CMS experiment at a centre-of-mass energy of 13 TeV. Our analysis focuses on the final states where the Higgs boson decays to a pair of tau leptons. We played a leading role in developing the multivariate discriminant based on boosted decision trees (BDT) for this analysis carried out using 2016 and 2017 data. Furthermore, we added a new final state with two hadronic tau leptons and no additional light leptons, and also performed studies on the normalization of Z→ tau tau backgrounds from data. The result of this analysis is published in EPJC, which provides an observed significance of close to 5 standard deviations.

We made significant 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 decay plane is constructed from the momentum vector of the charged pion combining with the momentum of neutral pion or the impact parameter of the charged pion with respect to the primary vertex. The analysis with full Run-2 data at 13 TeV provides a measured value of the CP mixing angle to be (4 +/- 17) degree and excludes a pure CP-odd state by 3.2 standard deviations.

We have measured the tau trigger performance in Run- 2 data at 13 TeV and obtained data-to-MC scale factors to be used in physics analyses for correcting MC simulations. A new method using Gaussian regression

technique is developed to perform a non-parametric fit to measured trigger efficiency curves to improve its modeling. We also measured efficiency for jet and missing transverse energy triggers with respect to that of offline objects. Especially, we also developed a new method for measuring the jet trigger efficiency with respect to its true jet energy scale by using Z(di-muon)+1-jet balancing method for the trigger level jet candidates.

We are assembling a functional test set up, which will be used to perform the functional tests of the silicon-strip tracker detector modules during their assembly. So far, components for electrical readout have procured and assembled. A test has been performed to check performance of the setup with an 8CBC3 hybrid. In addition, we prepared the laboratory space along with necessary infrastructure to carry out these measurements.

(A. K. Nayak)

2.4 Quantum Information

The quantum information group has been working in the area of Quantum Correlations, Quantum Nonlocality and Contextuality, Quantum Communication protocols, and Quantum Cryptography. In the area of quantum correlations, a new measure that can not only quantify correlations bust also local quantumness, was introduced. There are mixed states, which are mixtures of product states, but the local quantumness of the state is its integral part. The measure, that was introduced, is a fine-grained measure. One can also introduce a measure that can characterize the average quantum properties of a state. We also discuss a few applications of this measure.

In addition, a new cryptographic protocol for multipartite states has been introduced and the suitable resource states for three qubits are found. Using these resource states possibility of generating a conference key was studied. Violation of a set of previously introduced multipartite Bell inequalities help in detecting the presence of an intruder, Eve. This help in making the protocol secure. These resource states are also suitable for cooperative teleportation.

(P. Agrawal)

Quantum entanglement plays a pivotal role in many communication protocols. We considered a scenario where more than two parties were involved in a protocol and share a multipartite entangled state. In particular, we considered the protocol of Controlled Quantum Key Distribution (CoQKD), where, two parties, Alice and Bob establish a key with the cooperation of other parties. Other parties control/supervise whether Alice and Bob can establish the key, its security and key rate. In the case of three parties we found suitable resource states and discussed the controlling power of the third party, Charlie. We examined the usefulness of the new resource states for generating conference key and for cooperative teleportation. We found that recently introduced Bell inequalities can be useful to establish the security of the conference key. We also generalized the scenario to more than three parties.

We have introduced a new information theoretic measure of quantum correlations for multiparticle systems. We used a form of multivariate mutual information—the interaction information—and generalized it to multiparticle quantum systems. There are a number of different possible generalizations. We considered two of them. One of them is related to the notion of quantum discord and the other to the concept of quantum dissension. This new measure, called dissension vector, is a set of numbers—quantumness vector. This can be thought of as a fine-grained measure, as opposed to measures that quantify some average quantum properties of a system. These quantities quantify/characterize the correlations present in multiparticle states. We considered some multiqubit states and found that these quantities are responsive to different aspects of quantumness and correlations present in a state. We found that different dissension vectors could track the correlations (both classical and quantum) or quantumness only. As physical applications, we found that these vectors might be useful in several information processing tasks. We consider the role of dissension vectors—(a) in deciding the security of BB84 protocol against an eavesdropper and (b) in determining the possible role of correla- tions in the performance of Grover search algorithm. Specially, in the Grover search algorithm, we found that dissension vectors could detect the correlations and showed the maximum correlations when expected.

(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, S. Sahoo, D. Topwal, D. Samal)

1. Nanomaterials for biosensing and photodetectors:

Conjugated hybrid nanostructured Cu_2O-ZnO has been grown via the single-step co-electrodeposition (CED) technique. Though ZnO nanostructures grown alone by electro-deposition technique do not exhibit any glucose sensing, the CED- grown Cu_2O- ZnO nanostructures show non-enzymatic glucose sensing and amperometric behavior with very high sensitivity, large linear range, low detection limit and a fast response time. The CED growth process leads to development of conjugated hybrid nanostructured Cu_2O-ZnO that presents an excellent template for non-enzymatic glucose sensing.

The adsorption of DNA on a nanostructured SiOx substrates has been investigated in order to understand their binding behaviour. The XPS results reveal a rich picture where SiO_x appears to interact with the nitrogen bases of DNA via electrostatic interaction through transfer of charge. These results have been complemented with Quantum level calculations performed with DFT. The molecular electrostatic maps and molecular orbital maps, obtained via DFT, support the experimental findings. These results will be important for biosensing applications.

The surface dynamics of TiO_2 thin films, evolving under the implantation of 50 keV Ti ions, have been investigated. Ion irradiation experiments were carried out at IUAC, N. Delhi. The morphological evolution, as investigated with atomic force microscopy, delineates a surface smoothening by ion implantation. The nanoscale structures at surfaces also undergo a size reduction. Scaling formalism has been applied to understand this temporal and spatial dynamics by estimating the scaling exponents via Height-height correlation function and power spectral density (PSD) investigations.

The ultraviolet current response of single-crystal diamond photodetectors to the lifetimes of nitrogen-induced color centers has been investigated. Single-crystal diamond photodetectors are fabricated and characterized by optical and electrical measurements. As observed from the photocurrent studies, the magnitude of the current response rises up to five order in comparison to the dark condition. The charge carrier dynamics of the dominant color centers contributing to the response has been investigated.

The magnetic-order induced effects in nano-crystalline NiO are investigated through the phonons and magnons observed in the Raman spectra. The key observations show an anisotropy of the first-order transverse and longitudinal optical phonons along with a marked size and excitation wavelength variation of the two magnon peaks. The results have been interpreted in terms of the exchange interactions and strong electron-electron correlations. The magnetization measurements show a crossover to ferromagnetism with large coercivity and magnetization with decreasing size, which is shown to be due to the thermo-induced contributions.

(S. Varma)

2. Study of Topological Insulators using Angle Resolved Photoelectron Spectroscopy (ARPES):

Discovery of spin polarized non-trivial surface states (SSs) in bulk insulating materials

was a major breakthrough in the field of condensed matter physics. Various exotic states of these compounds, which are widely known as topological insulators (TIs), are being understood by using both experimental and theoretical tools. The origin of such unique SSs is the strong spin orbit coupling (SOC) and the small energy band gap in these materials together giving rise to an inversion of bands with opposite parity. These SSs are of non-trivial topology and hence stable against any perturbation, like disorder or impurities. The subtle interplay between spin orbit interaction (SOI) and the near Fermi level (E_f) electronic structure can also lead to other distinct systems, like Weyl semimetals, topological crystalline insulators, topological Dirac semimetals etc.. Several compounds have been theoretically predicted to host strong TI characters and many of them have also been experimentally realized, whereas only very few weak TIs have been identified till now. Using various experiments and band structure calculations we earlier have shown that BiSe is indeed a weak TI.

We have performed ARPES studies on compositions of BiSe, $Bi_{2-x}Cu_xSe$, $Bi_{1-x}Sb_xSe$ and Weyl semimatals like WTe_2, $ZrTe_2$ etc using both laboratory ARPES system at IOP and Synchrotron Radiation facility at Elettra, Italy. Our results using ARPES on single crystals of BiSe and a Sb doped version of it with formula $Bi_{0.92}Sb_{0.08}Se$ show that, contrary to the Bi_4I_4, there are Dirac like linearly dispersing SSBs on the top surface (001) of BiSe. Furthermore, the Dirac point (DP) is placed deep in the bulk valence band (BVB). Sb doping not only increases this overlap between the SSBs and BVB but affects the linearity of the SSBs dispersion as well. This behavior is quite different from those shown by the known TIs of the Bi family Bi_2Se_3. The difference could be due to the interlayer coupling between the Bi bilayer and the Bi_2Se_3 QL. Interestingly, we noticed an appreciable amount of intensity imbalance in the SSBs located at the positive and negative k|| directions and also it is sensitive to the variation in the excitation energy. This possibly indicates a mixing between the spin and the orbital texture in the SSBs. These results also highlight the role of the Bi bilayer existing between the adjacent Bi_2Se_3 QLs in this material which enhances the relaxation process for the photo-hole generated at the SSBs. Further, we have mapped the Fermi surface of BiTe using ARPES measure- ments. These materials show significan differences from those on BiSe, though BiTe is also a potential weak TI. Here also we have observed signatures of mixing between spin and orbital texture.

(B. R. Sekhar)

3. Ion-beam induced nanoscale self-organized patterning of materials and their functionalization, Thin film photovoltaics, Resistive Switching and neuromorphic devices:

This project focuses on the fabrication of self-organized patterned semiconductor substrates using low-to-medium energy (0.5-100 keV). At low ion energies, ripples are formed on Si surface which undergoes a transition to facets over a small angular window of the incident ion beams. Such differently patterned surfaces are fabricated towards their nanoscale functionalization, viz. cold cathode electron emission, plasmonics, and nanoscale magnetism where the patterned

substrates are employed as templates for growth of thin films by UHV e-beam evaporation or RF sputtering.

We have studied 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 making career selective contact-based Sb_2Se_3 photovoltaic cells.

Neuromorphic computing (or brain-inspired computing) is a promising concept for processing enormous information even at low-power with the capability of self-learning, cognitive adaptation, and recognition of speech, gesture, and objects. These human-brain-like features can be realized using artificial synapse network. 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 a memristor or resistive switching (RS) device, an active material is sandwiched between two electrodes. Fundamentally, the communication strength (potential) across bio-synapse increases with increasing number of incoming pulses. Similarly, conductance (current) across a RS device can gradually increases by applied electric pulses. In fact, a gradual change in the communication strength with increasing input pulses in bio-synapse and RS devices show great similarity. Thus, RS devices provide a unique opportunity to mimic the bio-synaptic functions at electronic level. In addition, RS devices have advantages of fast operation, scalability, and can be packed at higher densities which make it excellent to design neuromorphic devices. We are working on oxide thin film-based memristors like TiO_x and CZO to study artificial synapses at nanoscale, using atomic force microscopy, to emulate bio-brain features.

(T. Som)

4. Quantum materials and hybrid perovskites:

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 Structural, 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, like: next-generation photovoltaics materials.

We have shown that the formation of broad-band emissions related to self-trapped excitons in the sub-bandgap region in organic–inorganic hybrid perovskites can be controlled using a suitable sample synthesis procedure and has potential in optoelectronic device applications.

Angle resolved photoemission spectra of $MAPbCl_3$ are carried out and the experimental data is compared with two theoretical models (1) MA^+ is orientationally disordered (MA^+ ion is replaced by spherically symmetric Cs^+ ion) and (2) MA^+ is oriented along <100> direction. Our

results indicate that Model 1 provides a better picture of the orientationally disordered nature of the MA^+ ions.

In $GdMn_{1-x}Cr_xO_3$, JT distortion characteristic to Mn^{3+} results in bond anisotropy and effective orbital ordering for x 0.35. There is a gradual variation of electronic states with doping and magnetization (FC mode) shows sign reversal effects for x 0.35. The change in magnetic polarity at the critical concentration coinciding with JT crossover implies a complex interplay of magnetic interaction and structural distortion and is understood in terms of doping-induced modification of symmetric magnetic interactions (FM/AFM type).

(D. Topwal)

5. Atomically layered materials and metal oxide thinfilms:

Atomically thin semiconductors have versatile future applications in the information and communication technologies for the ultimate miniaturization of electronic components. In particular, the ongoing research demands not only a large-scale synthesis of pristine quality monolayer MoS_2 but also advanced nanofabrication and characterization methods for investigation of intrinsic device performances. In this report, we conduct a meticulous investigation of the fast transient charge trapping mechanisms in field-effect transistors (FETs) of high-quality CVD MoS_2 monolayers grown by a salt-driven method. To unfold the intrinsic transistor behavior, an amplitude sweep pulse I~V methodology is adapted with varying pulse widths. A significant increase in the field-effect mobility up to ~100% is achieved along with a hysteresis-free transfer characteristic by applying the shortest pulse. Moreover, to correlate these results, a single pulse time-domain drain current analysis is carried out to unleash the fast and slow transient charge trapping phenomena. Furthermore, rigorous density functional theory (DFT) calculations are implemented to inspect the effects of the Schottky barrier and metal-induced gap states between drain/source electrode and MoS_2 for the superior carrier transport.

Recent observation of stable quantized conductance in anatase TiO_2 resistive random access memory (ReRAM) devices opens up a new pathway towards realization of brain-inspired neuromorphic computing devices. Herein, for the first time ab-initio calculations are implemented to understand the resistive switching phenomena in anatase TiO_2. Oxygen vacancy configurations with different charge states are studied to get insight into the ON and OFF state of ReRAM devices. Among the tri-vacancy configurations, Vo^{+1} state is observed to induce highly dispersed defect states within the bandgap forming a charge density channel where the carriers behave as free electrons leading to the formation of conducting filament (CF). On the other hand, the breakdown of the CF is noticed by the removal of an oxygen vacancy from the tri-vacancy configuration. In this OFF-state, the defect state carriers are found to be highly localized. We have also investigated the effect of charge injection on the crystal field symmetry of the CF. The reduction of symmetry due to the tri-vacancy configuration lowers the e_g manifold energy whereas the di-vacancy configuration lowers the t_{2g} manifold energy.

(S. Sahoo)

6. Magnetic and electronic properties of complex oxide thin films/interfaces and transition metal chalcogenides:

Atomically engineered complex oxide layers and the designed interfaces are found to be a promising test-bed to explore emergent electromagnetic phenomena not attainable in bulk. In particular, artificial confinement of electrons by tailoring the layer thickness has turned out to be a powerful tool to harness control over competing phases in nano-layers of complex oxides. We use PLD technique to fabricate complex oxide thin films/interfaces and investigate the underlying electronic/ magnetic properties. As a part of complex oxide thin films/ interfaces study, we demonstrate the evidence of an unprecedented room temperature positive exchange bias (EB) and hysteresis loop inversion in monolithic $Y_3Fe_5O_{12}$ films grown epitaxially on a (111)-oriented $Gd_3Ga_5O_{12}$ (GGG) crystal, which may have strong implication for spintronics device applications. Second, we investigate the effect of dimensionality on transport properties of *d*-electron–based heavy-fermion metal $CaCu_3Ru_4O_{12}$. The transport behavior evolves from metallic to localized regime upon reducing thickness and the occurrence of weak antilocalization-weak localisation crossover is observed near metal-insulator transition. Magnetotransport study further reveals a strong interplay between inelastic and spin-orbit scattering lengths upon reducing thickness, which results in weak antilocalization (WAL) to weak localization (WL) crossover in magnetoconductance.

In view of the research activities in bulk chalcogenides, we observe the unusual effect of Mg intercalation on the superconductivity in bulk 2H-Mg_xNbSe_2. 2H-$NbSe_2$ is a phonon mediated, multiband superconductor. The interplay between charge density wave and superconductivity in 2H-$NbSe_2$ is complex. Usually, the intercalation in 2H-$NbSe_2$ enriches the CDW, enhances *c*-axis lattice parameter, and distorts the Fermi surface, which results in decrease in the superconducting transition temperature (T_c). The rate of decrease of T_c depends on the electronic structure, size, valence, magnetic nature, and electronegativity of the intercalating species. Unlike other *s* and *p* block elements/species as intercalants (Rb, Sn, Ga, Al) that have sharp detrimental effect on the superconducting T_c in 2H-$NbSe_2$ within 1-5% of intercalation, Mg is found to be an exception and has nominal effect on superconductivity.

In an attempt to write a review article on the group 10 transition metal dichalcogenides (MX_2: M = Ni, Pd, Pt; X= S, Se, Te) which have attracted much attention in the recent days, we survey the crystal and electronic structure, superconductivity, topological phases, spin texture and Rashba effect, magnetic properties and thermoelectric properties in the bulk as well as in atomically thin transition metal dichalcogenide materials.

(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. Floquet generation of Higher Order Topological Systems

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. Interestingly, Floquet engineering by suitably tuning appropriate perturbation can lead to Floquet Higher Order Topological Superconducting (HOTSC) phases starting from a lower order or non-topological phases. In this direction, we theoretically investigate the Floquet generation of second-order topological superconducting (SOTSC) phase, hosting Majorana corner modes (MCMs), considering a quantum spin Hall insulator (QSHI) with proximity induced superconducting *s*-wave pairing in it. Our dynamical prescription consists of the periodic kick in time-reversal symmetry breaking in-plane magnetic field and four-fold rotational symmetry breaking mass term. Furthermore, starting from a *d*-wave superconducting pairing gap, we periodically kick the mass term to engineer the dynamical SOTSC phase (both in 2D and 3D) within a specific range of the strength of the drive. The SOTSC phase hosts MCMs and Majorana Hinge Modes (MHMs) in 2D and 3D respectively. We characterize the topological nature of these phases by appropriate topological invariant like Floquet quadrupolar moment and Floquet Wannier Spectrum. Currently, we are working on how to engineer the anomalous dynamical higher order Majorana modes via step as well as periodic driving and the effect of disorder on them.

Impact of Strong Correlation in Topological systems

In our research work in this direction, we investigate the impact of strong correlations (Hubbard interaction) on a first order band topological insulator on the Lieb lattice. We show that beyond a critical correlation strength U_c, there is a sudden transition to a Mott insulating state, where the flat band (FB) is destroyed due to complete transfer of spectral weight from the FB to the upper and lower bands. We also show that all the correlation driven insulating phases host edge modes with linearly dispersing bands along with a FB passing through the Dirac point, exhibiting that the topological nature of the bulk band structure remains intact in the presence of strong correlation.

In our recent work, we consider a triangular lattice with onsite Coulomb interaction U present only on one sub-lattice, is periodically driven by electromagnetic field with a frequency W >> (t; U) at half filling. In this high frequency limit and U = 0, the driving sets in an emergent intrinsic spin-orbit coupling term and stabilizes three dispersive bands with the lower and upper bands exhibiting topological character with non-zero Chern numbers. In presence of on-site Hubbard interaction, we show that while U freezes out charge fluctuations on the interacting sub-lattice, it does not open up a charge gap without the external drive. In presence of the drive, and small U, the system exhibits repeated metal-insulator transitions as a function of the drive amplitude A. For large U, we establish that the freezing of charge fluctuations on the interacting sub-lattice stabilizes an emergent, low energy half-filled non-interacting "Kane-Mele model", whose band

gaps can be tuned by varying A. This provides a handle to engineer periodic topological phase transitions characterized by swapping of band Chern numbers. Currently, we are working on the effect of doping and emergence of magnetism in the topological Mott phase.

(A. Saha)

2. We consider a time reversal symmetry (TRS) broken Kane-Mele model superimposed with Haldane model and chart out the phase diagram using spin Chern number to investigate the fate of quantum anomalous Hall insulator (QAHI) and quantum spin Hall insulator (QSHI) phases. Interestingly, in addition to QSHI and QAHI phase, the phase diagram unveils quantum anomalous spin Hall insulator (QASHI) phase where only one spin sector is topological. We also find multicritical points where three / four topological phase boundaries coalesce. These topological phases are protected by an effective TRS and a composite anti-unitary particle-hole symmetry leading to remarkable properties of edge modes. We find spin-selective, spin-polarized and spin-neutral edge transport in QASHI, QSHI and QAHI phases respectively. Our study indicates that the robustness of the topological phase mainly depends on the spin gap which does not necessarily vanish at the Dirac points across a topological phase transition. We believe that our proposals can be tested in near future using recent experimental advancements in solid state and cold atomic systems.

In another work, we investigate the Heisenberg model on a decorated square (Fisher) lattice in the presence of first-neighbor J_1, second-neighbor J_2, and third-neighbor J_3 exchange couplings, with antiferromagnetic J_1. The classical ground-state phase diagram obtained within a Luttinger-Tisza framework is spanned by two antiferromagnetically ordered phases, and an infinitely degenerate antiferromagnetic chain phase. Employing classical Monte Carlo simulations, we show that thermal fluctuations fail to lift the degeneracy of the antiferromagnetic chain phase. Interestingly, the spin-wave spectrum of the Néel state displays three Dirac nodal loops out of which two are symmetry protected while for the antiferromagnetic chain phase we find symmetry-protected Dirac lines. Furthermore, we investigate the spin S=12 limit employing a bond operator formalism which captures the singlet-triplet dynamics, and find a rich ground-state phase diagram host to a variety of valence bond solid orders in addition to antiferromagnetically ordered phases.

(S. Mandal)

3. The focus of our group is on active matter and biological physics.

Along with my PhD student, Amir Shee, and collaborators, we have recently shown a remarkable mapping of the trajectories of active Brownian particles to equilibrium semiflexible polymers, using a path integral formulation. This opens up tremendous possibility of idea exchange between the two communities of polymer physics and active matter, and allowed us to use a Laplace transform method developed earlier in polymer physics to exactly determine arbitrary moments of ABP dynamics in general d-dimensions. The displacement distribution of ABP shows a transition from the Gaussian to the bimodal distributions typical of worm- like- chain model of polymers.

In experiments, ABPs in harmonic trap has shown crossover from Gaussian to non- Gaussian distribution of position with increasing trap stiffness. We developed and used an exact calculation based on the Fokker-Planck equation describing the particle motion that not only provides a physical understanding of such observations but further predicts a re-entrant transition depending on the activity and trap stiffness. Our analytical calculations clearly demonstrate a re-entrant transition for the system in the presence of thermal translational diffusion, from the passive Gaussian like distribution of particle positions to a stronger localization away from the trap centre, back to the Gaussian form with increasing trap stiffness.

In biological systems, our recent focus has been on understanding properties of cytoskeletal complex involving motor proteins and semiflexible filaments. We studied the dynamics of a rigid filament in a motor protein assay under external loading in one dimension, using an active extensible spring model of the motor proteins. We utilize numerical simulations, a Fokker-Planck based mean field theory, and linear stability analysis to obtain various dynamical phases and phase transitions. Under constant loading, the system shows a transition from a stable configuration to instability towards detachment of the filament from the motor proteins. Under elastic loading, we find the emergence of stable limit cycle oscillations via a supercritical Hopf bifurcation with a change in activity and the number of motor proteins. The number of motor proteins required at the onset of limit cycle oscillations increases with the increasing stiffness of the elastic loading. We further consider dynamics of a semiflexible filament in a gliding assay of molecular motors to find phase transitions between open chain and spiral conformations. The detailed phase diagram and dynamics is described within mean field using an effective entropy functional.

Finally, in our most recent communication we presented a study of the coupled dynamics of the shape fluctuations of a spherical membrane associated with diffusible membrane-bound activator proteins, and actomyosin cytoskeleton. Our field theoretic investigation reveals instability towards long wavelength pattern formation, localized pulsation and running wave in the polar direction. We used linear stability analysis and numerical integration to demonstrate the detailed dynamical phase behavior. Our results have implications for animal cells near cell division and artificial cell constructs.

(D. Chaudhuri)

PUBLICATIONS

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R. Kumar, S.N. Sarangi, D. Samal, and Z. Hossain, Phys. Rev. B 103, 064421 (2021)

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M.K. Hooda, C.S. Yadav and D. Samal, J. Phys.: Condens. Matter (Topical Review) 33, 103001 (2021)

71. **A comparative study on the magnetic properties of undoped and Li-doped $Cu(OH)_2$-CuO**

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I. Ahmad, J.S. Hansdah, S.N. Sarangi, P.M. Sarun, Journal of Alloys and Compounds 834, 155033 (2020)

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S. Dolai, R. Dey, S.N. Sarangi, S. Hussain, R. Bhar, A.K. Pal, Journal of Magnetism and Magneti Materials 495, 165903 (2020)

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S. Saini, S. Reshmi, G.M. Gouda, A. Kumar S. Sriram K.V., and K. Bhattacharjee, Nanoscale Adv. 3, 3184 (2021)

83. **Atomic adsorption of Sn on mechanically cleaved WS2 surface at room temperature**

M. Mohan, V.K. Singh, S. Reshmi, S.R. Barman, K. Bhattacharjee; Surface Science 701, 121685 (2020)

84. **Analyticity and Causality in conformal field theory**

J. Maharana, Mod. Phys. Lett. A35, 2050186 (2020)

85. **Proof of Dispersion relations for the amplitude in theories with compact space dimension**

J. Maharana, JHEP 06, 139 (2020)

86. **Forming-free resistive switching in ferroelectric $Bi_{0.97}Y_{0.03}Fe_{0.95}Sc_{0.05}O_3$ film for RRAM application**

A.K. Jena, H.N. Mohanty, J. Mohanty, Physica Scripta 96, 045808 (2021)

87. **Light sterile neutrinos and their implications on currently running long-baseline and neutri noless double-beta decay experiments**

R. Majhi, C. Soumya, and R. Mohanta, J. Phys. G: Nucl. Part. Phys. 47, 095002 (2020)

88. **Exploring the effect of Lorentz invariance violation with the currently running long-baseline experiments**

R. Majhi, C. Soumya, and R. Mohanta, Eur. Phys. J. C 80 5, 364 (2020)

- **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 2020-2021 are 34

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

IOP is a part of CMS collaboration (Dr. A.K. Nayak) and total number of publications for the year 2020-2021 are 75

3.2 Conference proceedings

1. **Lorentz Invariance Violation and Long Baseline Experiments**

Rudra Majhi, C Soumya, and Rukmani Mohanta, Springer Proc. Phys. 248, 349-353 (2020)

3.3 Books/ Book Chapters

1. **Nuclear Structure Physics** (Book)

A. Shukla and S. K. Patra, CRC Press, 2020

2. **Bioapplication of Inorganic Nanomaterials** (Book Chapter)

S. N. Sarangi and S. Nozaki, Handbook: Bioinspired Systems and Methods (Volume Seven) 1st Edition Edited by Klaus D. Sattler, Publisher: Taylor & Francis Group, CRC-Press, Pages 7-14, (2020)

3.4 Other Publications (by Library Staff)

- B. Mohanty, J. Sahoo, & N.K. Dash (2020). Assessing the Research Impact of Scholarly Communications using Scientometric Indicators: A study on Information Systems Management Journal, Library Philosophy and Practice (e-journal), 2020 (4207), 1-22.
- S. Mundhial, J. Sahoo, N.K. Dash, & B. Mohanty (2020). Indian Doctoral Research in the Field of Library and Information Science: An Empirical Analysis. International Information & Library Review, 52(4), 1-16; doi:10.1080/10572317.2020.1849914.
- S. Patra, J. Sahoo, & Mohanty, B. & S. Mundhial (2021). Research on Digital Preservation: An empirical analysis, Library Philosophy and Practice (e-journal), 2021 (5428), 1-17.
- S. Mundhial, J. Sahoo, N.K. Dash, & B. Mohanty (2021). Research Trend in Library and Information Science in India - A Study (Book Chapter) in Ashraf, T., Naqvi, S. H., Ahmad, S. & Khan, H. R. (eds.), Emerging Trends & Technologies in Library Services: An Exploration; Synergy Books : India, ISBN- 9788194843061, pp. 143-152.

3.5. (A) AWARDS / HONOURS AND RECOGNITIONS BY FACULTY

Prof. Shikha Varma

- Editorial Board Member of International 'Journal of Physics: Condensed Matter' of IOP-Publishing Bristol UK
- Review Editorial Board member of International Journal 'Frontier'

Prof. T. Som

- Member, Review Committee, DST Solar PV Hub at IIEST, Shibpur
- Member, International Scientific Committee on Biennial "International Workshop on Nanopatterning"

Prof. Sanjib K Agarwalla

- The Department of Science and Technology (DST) Swarnajayanti Fellowship 2019-2020
- The N. S. Satya Murthy Memorial Award 2020 by the Indian Physics Association (IPA)
- Young Scientist Research Grant for three years (2018 to 2021) from INSA

Dr. Saptarshi Mandal

- Awarded ICTP Associates 2020-2025

Dr. Aruna Kumar Nayak

- Appointed as a convener of the group on Strategy for Trigger Evolution and Monitoring (STEAM) by the CMS collaboration for two years (September 2020 to August 2022). This is a Level-2 convener position under CMS Trigger Coordination.

Dr. Debasish Chaudhuri

- Dr. Debasish Chaudhuri as an Associate of the International Center for Theoretical Studies (ICTS) – TIFR, Bangalore during the period of January, 2020 to December, 2022.

Dr. Kirtiman Ghosh

- Elected as IASc Associate (2020-2023)

Dr. Manimala Mitra

- Received the prestigious Indo-French bilateral research grant from Indo-French Centre for the Promotion of Advanced Research (CEFIPRA) in June 2020. The partner institute from Indian side is IISc with Prof. Rohini M. Godbole as a Co-PI in this project. The PI from French side is Prof. Genevieve Belanger, LAPTh, and Annecy, France.

3.5. (B) AWARDS / HONOURS AND RECOGNITIONS BY SCHOLARS

- Mr. Bibhabasu De has received Best Poster award at "DAE-HEP-2020" Symposium.

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OTHER ACTIVITIES

4.1 Foundation Day

On September 4, 2020, the 46th Foundation day of the Institute was observed. The day was marked in low key due to the pandemic and the sad demise of India's ex-President. Due to the pandemic situation, only about 20 persons were physically present. However, everybody could join over the Google Meet or YouTube link.

During the program, a message from the Director, Prof. S. M. Yusuf was read, and the institute activity report was presented. Retired employees were also felicitated. In the academic part of the program, Dr. Rajeev Swain of the Institute of Life Sciences gave a talk on a timely topic, "COVID-19 pandemic: How it started and how it may end". The program ended with a vote of thanks by the Registrar.

Foundation Day Celebration

Talk by Dr. Rajeev Swain, ILS, Bhubaneswar

4.2 Outreach Programme

Prof. A. M. Srivastava

1. Hosted online Discussion on the topic: "Motion" in the Physics Open Discussion (POD) session organized by the Bigyan Chetana Manch, Bhubaneswar for school students on 27th September 2020.
2. Conducted night sky-view session on the occasion of The **Jupiter-Saturn great conjunction,** on 21st December 2020, at IOP Bhubaneswar. The program was conducted with an 8" Schmidt-Cassegrain 2 meter focal length telescope (computer-controlled with a GPS system), for IOP members and their families, with the strict following of Covid-safety norms.
3. Hosted the Physics Open Discussion (POD) session at Cohen International School, 3rd January 2021.

4. Hosted the Physics Open Discussion (POD) session for school students with Bigyan Chetana manch, 30th January 2021.

4.3 Activities of Official Language Cell

Official Language Implementation

In pursuance of the Official Language Policy of the Government of India, Rajbhasha Ekak of the Institute is promoting the progressive use of Hindi in IIT Bhubaneswar. Presently the Cell has one sanctioned post of Junior Hindi Translator, which is lying vacant. The Institute is wholly tried to follow the rules and regulations of the Govt. of India related to Official Languages Hindi by deputing other staffs and officers of the Institute. Some of

On-Going Activities

Translation of Institute Annual Report, Annual Accounts, Audit Report and various other documents which comes under Section 3(3) of Official Language Act, 1963. In addition, various other letters and correspondence, replies etc., are either translated or prepared in Hindi. The Rajbhasha Ekak also try to ensure the effective implementation of the Official Language policy of Govt. of India at the Institute. The Ekak ensures the bilingual display and use of different nameplates, notice boards, rubber stamps, routine type forms and also help in preparing bilingual Degrees certificate awarded by the Institute.

Hindi Workshop

Hindi Training and Workshop Time to time, Rajbhasha Anubahg impart Hindi training to all Institute employees who have no working knowledge in Hindi. To solve the problem faced by the employees in using the official language, the Rajbhasha Anubhag organised workshops/training for the employees of the Institute and member office of TOLIC Bhubaneswar. In the reporting year, the following workshops were organised: Role of Technicians in Implementation of Official Language on 26.03.2021, Use of Technologies in Implementation of Official Language on 30.12.2020, An Introduction: Department of Atomic Energy on 29.06.2020.

Hindi Pakhwada-2020

Hindi Pakhwada Ceremony During 14-28 September 2020 Institute organised "Hindi Pakhwada" in the Institute. Several Programmes and competitions in Hindi were organised for employees and students of our Institute and as well as for students of neighbouring institutes during the 14 days long Hindi Pakhwada.. On 14th September 2020, Hindi Diwas was celebrated in the institute collabotation with Institute of Life Sciences, Bhuabaneswar. Hon'ble Director I/c. Prof. Pankaj Agarwal graced the occasion. In his speech, he praised the winners of various competitions and said that

Celebration of Hindi Pakhwada

Institute is committed to implement Rajbhasha Policies of the Govt. of India. Sri R. K. Rath, Registrar was also present and highlighted institute efforts in implementing the Rajbhasa policies of the Government. The message of Hon'ble Home Minister Govt. of India and message of the Chairman, Atomice Energy Commission were read on this occasion. Various popular talks in Hindi organized during Hindi Pakhwada.

4.4 SWACHHA BHARAT ABHIYAN ACTIVITIES

The Swachhta Pakhwada, launched by the Government of India, is a fortnight-long program observed to ensure mass participation of citizens in Swachhta activities and to transform Swachh Bharat into a citizen's movement truly.

E-pledges

This year, Swachh Bharat Pakhwada, 2021, was once again being observed by the Institute of Physics, Bhubaneswar, with zeal and vigor from 16th to 28th February 2021. The Pakhwada has been flagged off in the Institute by taking the Swachhta E-pledge. The Swachhta Shapathin bilingual (Hindi and English) format was made available on the internal portal of the Institute portal. Swachhta awareness banners have also been placed at prominent locations in various institutes.

In the current times of global pandemic, it has been ensured that the electronic version of the pledge was made available on the internal portal of the Institute to enable all employees to access the pledge remotely to read and take the pledge from their homes/workplaces itself.

Swachhata Activities

As a part of the Swachhata Pakhwada, Shrama Dan programme was conducted from 17.02.2021 to 28.02.2021 nearby areas of the Institute to clean the areas of public gathering places, drainage channels and other areas of the campus.

Swachhta Awareness Campaign

Awareness cum Sramadan campaign was conducted in collaboration with ICE Foundation on 19.02.2021 in the Durgamadhabpur village, Distt: - Puri, Odisha.

Medical premises is cleaned by Prof. S. Verma, Director I/c. Sri R. K. Rath, Registrar, Sri M.V. Vanjeeswaran and other staff members of the Institute during Swachhata activities.

Villagers of the Dugamadhabpur are being explained about the Swachhata programme of the Govt. of India

4.5 Sports and Curtural Activities

Along with the scientific activities, IOP continued to carry out sports activities to promote different sports and cultural programs to keep all the members physically fit. The IOP Employees Welfare Society conducted these various sports and cultural activities in IOP.

Prize giving day of IOP Annual Sport

The members of the welfare society are Prof (Dr.) Suresh Kumar Patra (President), Dr. Arjit Saha, Sri Bhagaban Behera (Secretary), Sri Balakrushna Dash (Sport's Convener), Smt Ajita. Kujur, Sri Priyabrata Patra, Sri Rajesh Mahapatra, Sri Brundabana Mohanty (Cultural Convener).

Due to the COVID-19 pandemic, the prize-giving ceremony of the IOP Annual Sports and Cultural Meet of 2019 along with the Annual Sports and Cultural Meet of 2020, friendly football match of 15th August 2020 and many activities could not be conducted in the year 2020.

However, the prize-giving ceremony of the Annual Sports and Cultural Meet of 2019 was organized on 26th January of 2021 under the guidelines of COVID-19 safety protocols. In the Annual Sports, the total number of events was 17. Around 55 staff members participated in men's events, 30 family members participated in the women's events, and 40 children participated in children's events. Among staffs, 20 volunteers coordinated for the successful completion of the events. Also, few staff members were rewarded, those who had completed 25 years of service at IOP.

4.6. Other Activities

4.6.1. Republic Day Celebration

Our Institute celebrated India's **72nd Republic Day** with great eclat. The members took pride in glorifying and celebrating the spirit of unity. The programme began at **9.15 am.** Our Director I/c. Prof. Shikha Varma hoisted the National flag, the members saluted the National flag and pledged to up hold the honour and integrity. The children group presented the patriotic Odia song followed by singing the National Anthem.

6.6.2. Tree Plantation Programme

A tree plantation programme was arranged on 16.07.2021 in the Institute. About 40 numbers of saplings were planted during this programme.

Republic Day-2021 celebration of the Institute

Saplings plantation by the Institute members

4.6.3 IOPEWS Foundation Day Celebration

Institute of Physics Employees Welfare Society celebrated its 5th Foundation Day on 01.01.2021. Sri R. K. Rath, Registrar, IOP, was the Chief Guest at the function. All the members attended this function.

5th Foundation Day of IOPEWS

4.6.4 74th Independence Day Celebration

IOP Bhubaneswar celebrated the 74th Independence Day at its campus by adhering to social distancing and other norms as per Govt. protocol amidst the Covid-19 pandemic. Prof. Pankaj Agarwal, Director I/c. of the Institute, hoisted the National Flag, offered floral tribute to Bharat Mata and delivered his Independence Day address followed by the National Anthem, sung by everyone in a rhythmic chorus.

Celebration of Independence Day

4.6.5. Women Cell Activities

This year the theme for International Women's Day (8 March) was "Women in leadership: Achieving an equal future in a COVID-19 world." It was to celebrate the tremendous efforts of women and girls around the world in shaping an equal future and recovery from the pandemic.

On the occasion of the Women's day, online talks were arranged by Women-cell of IOP on 8th March 2021. The talks were given by Prof. S.M. Yusuf, Director, IOP, Ms. Sushma Taishete, Joint Secretary R&D, DAE, Mumbai, and Prof. Sulabha Kulkarni, Senior scientist NASI, CMET, Pune. Due to the pandemic, the meeting was held in hybrid mode, with speakers and many IOP members present online and some members present in the lecture hall (block-B) of IOP, maintaining the social distance and other Covid related protocols.

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

Program dated 8th March 2021: (from top left) some members in the lecture hall, Prof. Sulabha Kulkarni, Prof. S.M. Yusuf, Ms. Sushma Taishete and IOP members.

Members (including Prof. Shikha Varma and the Registrar) in the lecture hall of IOP on 8th March 2021.

She thanked the Director, as well as the Registrar, administration and computer center of IOP, for facilitating the program and other IOP members for their enthusiasm.

Prof. S.M. Yusuf remarked that, as a Vice President of the Indian Physics Association (IPA), he has been involved in gender equity activities of IPA and had inaugurated the conference 'Pressing for progress-towards Gender Equity in Physics', at the University of Hyderabad. Prof. Yusuf in his talk, presented some salient features of the Women Cell and Internal Complaints Committee ("ICC") of IOP. He also mentioned various activities that have been undertaken by the Women Cell, IOP in promoting the message of gender equity in science. He further highlighted the efforts undertaken by IOP scientists and members in encouraging girls and women towards a career in science. He highlighted the need to bring more women as faculty and staff in IOP.

Ms. Sushma Taishete, Joint Secretary (R & D), DAE, first thanked Prof. Yusuf for the invitation and expressed satisfaction that Director, IOP, has taken a direct interest in such an event and spoke on this occasion. Then she gave a very motivating presentation on the difficulties that are faced by women in many of their endeavours and the roads that they can take to overcome these difficulties. She presented many examples, from her experiences, of many girls and women who could achieve distinction despite problems. In this direction, she also presented her impactful journey and the role played by many, around her, in her successful achievements. She stressed the importance of hard work and the desire of high goals in girls for achieving successful targets.

Prof. Sulabha Kulkarni presented a talk entitled 'Contribution of Women in Science and Technology.' After discussing the challenges faced by women during the 16th to 19th centuries, she

gave a lucid historical perspective on the contributions of many women scientists, mathematicians, artists, educationists, doctors who made significant contributions, despite not much support. She also presented the illustrative journey of several women who have made significant contributions to science but have not received due recognition. She mentioned the various schemes taken up by Govt. of India in encouraging the girls and women scientists.

The response of the audience for the talks was very enthusiastic and positive. The Women Cell of IOP plans to organize more such discussions and presentations. The event ended with remarks on occasion by Prof. Shikha Varma, Chairperson of Women Cell, IOP.

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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 Photoelectron 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 CENTRE

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.

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).

5.3. ANUNET FACILITY

Institute of Physics is a node on ANUNET with the provision to connect other units of DAE

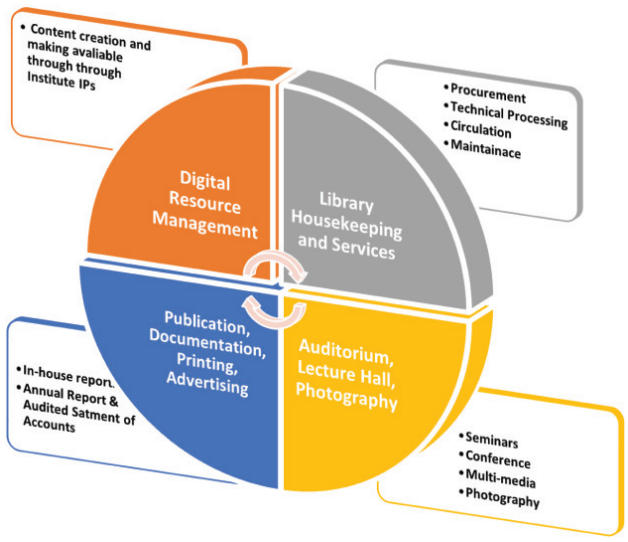
directly by VSAT link for voice and data communication. Seismic monitoring equipment has been installed in the Institute and seismic data is being continuously transmitted to Bhabha Atomic Research Centre (BARC) for analysis using ANUNET. The link is also used to connect with DAE and other institute 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 mandate of the IOP Resource Center is to select, acquire, process, and disseminate print and electronic / digital scientific and technical resources for the research community's information needs and other associated members. On the other hand, IOP General Library aims to serve the IOP community's requirement 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 auditorium with lecture hall services. Besides these other related activities, such as conducting conferences/seminars, IOP Library also cares for outreach programs. The IOP Library's activities are mirrored in the figure given here.

The Library holdings include 17035 books, 6000+ e-books, and 23,643 bound Journals as its own collection. The Library subscribes to 135 e-journals, some print Journals/Magazines and web tools like iThenticate & Grammarly. The house keeping activities of the Library is managed by the RFID based Smart Library Solution through KOHA Library Management System (LMS). The detailed holdings of the Library and associated facilities can be accessed from Library Portal @ http://www.iopb.res.in/~library. 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 in the periodic interval. The Library also supports many extension services, namely Study Tour of LIS students, Project/Dissertations of LIS students.



5.5 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. Arun M. Jayannavar**
(Retired on 31.07.2020)
Sr. Professor
Condensed Matter Physics *(Theory)*
2. **Prof. Ajit Mohan Srivastava**
Professor
High Energy Physics *(Theory)*
3. **Prof. Shikha Varma**
Professor
Condensed Matter Physics *(Experiment)*
4. **Prof. Pankaj Agrawal**
Professor
High Energy Physics *(Theory)*
5. **Prof. Biju Raja Sekhar**
Professor
Condensed Matter Physics *(Experiment)*
6. **Prof. Sudipta Mukherji**
Professor
High Energy Physics *(Theory)*
7. **Prof. Suresh Kumar Patra**
Professor
Nuclear Physics *(Theory)*
8. **Prof. Tapobrata Som**
Professor
Condensed Matter Physics *(Experiment)*
9. **Prof. Goutam Tripathy**
Associate Professor
Condensed Matter Physics *(Theory)*
10. **Prof. Pradip Kumar Sahu**
Professor
Nuclear Physics *(Theory)*
11. **Dr. Dinesh Topwal**
Reader – F
Condensed Matter Physics *(Experiment)*
12. **Dr. Sanjib Kumar Agarwalla**
Associate Professor
High Energy Physics *(Theory)*
13. **Prof. Arijit Saha**
Associate Professor
Condensed Matter Physics *(Theory)*
14. **Dr. Saptarshi Mandal**
Reader - F
Condensed Matter Physics *(Theory)*
15. **Dr. Satyaprakash Sahoo**
Reader - F
Condensed Matter Physics *(Experiment)*
16. **Dr. Aruna Kumar Nayak**
Reader-F
High Energy Physics *(Experiment)*
17. **Prof. Debashis Chaudhuri**
Associate Professor
Condensed Matter Physics *(Theory)*
18. **Prof. Shamik Banerjee**
Reader - F
High Energy Physics *(Theory)*
19. **Dr. Debakanta Samal**
Reader - F
Condensed Matter Physics *(Experiment)*
20. **Dr. Debottam Das**
Reader - F
High Energy Physics *(Theory)*
21. **Dr. Manimala Mitra**
Reader - F
High Energy Physics *(Theory)*
22. **Dr. Kirtiman Ghosh**
Reader - F
High Energy Physics *(Theory)*

6.2. Inspire/Visiting Faculty

1. Dr. Kuntala Bhattacharjee
2. Dr. Aparajita Mandal

6.3. Post-Doctoral Fellows

1. Dr. Biplab Bhattacahrjee
2. Dr. Sudheer
3. Dr. Sitendra Pratap Kashyap
4. Dr. Manpreet Kaur
5. Dr. Dr. Karan Singh
6. Dr. Dr. K.G. Paulson
7. Dr. Dibyakrupa Sahoo
8. Dr. Anjan Kumar Jena
9. Dr. R. Bhattacharyya
10. Dr. Rakesh Kumar Sahoo
11. Dr. S. S. Khali
12. Dr. Siddharth Dwivedi
13. Dr. Krishnanu Sadhukhan
14. Dr. Mandeep K Hooda
15. Dr. Debashree Choudhury
16. Dr. Soumya C *(NPDF)*

6.4. Doctoral Scholars

1. Alapan Dutta
2. Amir Shee
3. Atanu Maity
4. Dilruba Hasina
5. Ithineni Sairam
6. Rameswar Sahu
7. Sanu Varghese
8. Sheikh Moonsun Pervez
9. Subhadip Bisal
10. Debasish Mondal
11. Dipak Maity
12. Digbijaya Palai
13. Abhishek Roy
14. Aisha Khatun
15. Ankit Kumar
16. Arnob Kumar Ghosh
17. Arpan Sinha
18. Chitrak Karan
19. Harish Chandra Das
20. Mousam Charan Sahu
21. Pragyanprasu Swain
22. Ritam Kundu
23. Sameer Kumar Mallik
24. Sandhyarani Sahoo
25. Siddharth Prasad Maharathy
26. Sudipta Das
27. Bibhabasu De
28. Diwakar
29. Pranjal Pandey
30. Rupam Mandal
31. Saiyad Ashanujjaman
32. Rojalin Padhan
33. Gupteswar Sabat,
34. Abhisek Bag
35. Avnish

36. Debjyoti Majumdar
37. Sayan Jana
38. Subhadip Jana
39. Vinaykrishnan M.B.
40. Sudarshan Saha

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. Abhisek Maharik
2. Abhimanyu Behera

(iii) Establishment

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

(iv) Stores & Transport

1. Sahadev Jena *(up to 31.01.2021)*
2. Pramod Kumar Senapati
3. Sanatan Jena
4. Sarat Chandra Pradhan
5. Jahangiri Khan
6. Keshaba Chandra Dakua
7. D. Govinda Rao

(v) EPABX

1. Arakhita Sahoo
2. Daitari Das

(vi) Accounts

1. Debendranath Sahoo
2. Bhaskar Mishra
3. Prativa Choudhury
4. Sahadev Jena *(up to 31.01.2021)*
5. Rajesh Mohapatra
6. Priyabrata Patra
7. Jyoti Ranjan Behera
8. Bijaya Kumar Das
9. Bansidhar Panigrahi *(up to 30.04.2020)*

(vii) Maintenance

1. Arun Kanta Dash
2. Debaraj Bhuyan
3. Bansidhar Behera
4. Brundaban Mohanty
5. Deba Prasad Nanda
6. Naba Kishore Jhankar

7. Umesh Ch. Pradhan
8. Biswa Ranjan Behera
9. Kapila Pradhan
10. Martin Pradhan
11. Chandra Mohan Hansdah

(viii) Estate Management

1. Saroj Kumar Jena
2. Ramakanta Nayak
3. Gangadhar Hembram (upto 30.04.2021)
4. Tikan Kumar Parida
5. Biswanath Swain
6. Bijaya Kumar Swain
7. Sanatan Pradhan
8. Bhaskara Mallick
9. Kulamani Ojha
10. Pitabas Barik
11. Dhoba Naik
12. Charan Bhoi
13. Jatindra Nath Bastia
14. Basanta Kumar Naik
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. M. Shidhabatti
2. Nageswari Majhi

(xi) Laboratory

1. Sanjib Kumar Sahu
2. Sachindra Nath Sarangi
3. Khirod Chandra Patra
4. Madhusudan Majhi
5. Ramarani Dash
6. Santosh Kumar Choudhury
7. 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

(xiii) Purchase Section

1. Aviram Sahoo
2. Ghanashyam Pradhan

6.7. List of Retired Members

Shri Bansidhar Panigrahi

Designation : MTS-C

DoJ : 08.04.1982

DoR : 30.04.2020

Shri A.M. Jayannavar

Designation : Senior Professor

DoJ : 15.04.1991

DoR : 31.07.2020

Shri Sahadev Jena

Designation : Senior Assistant

DoJ : 08.04.1982

DoR : 31.01.2021

परीक्षित लेखा विवरण
AUDITED STATEMENT OF ACCOUNTS
2020-21

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, 2021, and the Statement of Income and Expenditure and the Statement of 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.

Qualified opinion

Basis of Qualification:

1.

a) The Society has not followed AS 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 AS 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. Profit of the Society is understated to the tune of Rs59000/- (Rupees Fifty-Nine Thousand) the amount of audit fees for the previous year charged to the current year Income and Expenditure Account.

Matter of emphasis:

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 Policy 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 2021
b. In the case of the statement of income and expenditure, of the deficit of the society for the year ended on that date.
c. In case of statement of receipt and payments, the receipts and payment of the society for the year ended on the date.

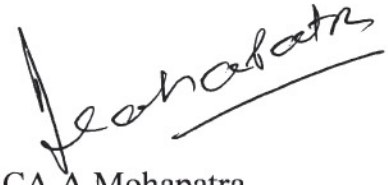
Report on other legal and regulatory requirements

(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 Society, 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: 21055285AAAAEB4732

Place: Bhubaneswar
Date: The 13th Day of October, 2021

INSTITUTE OF PHYSICS
Sachivalaya Marg, Bhubaneswar

Balance Sheet as at 31st March 2021

(Amount in Rupees)

SOURCES OF FUNDS	Schedule	Current Year	Previous Year
CORPUS/ CAPITAL FUND AND LIABILITIES			
CORPUS/ CAPITAL FUND	1	57,99,14,871	64,15,57,802
RESERVES AND SURPLUS	2	-	-
EARMARKED/ENDOWMENT FUNDS	3	2,28,45,629	1,13,65,499
SECURED LOANS AND BORROWINGS	4	-	-
UNSECURED LOANS AND BORROWINGS	5	-	-
DEFFERED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	16,34,58,804	15,26,57,687
TOTAL		**76,62,19,304**	**80,55,80,988**

APPLICATION OF FUNDS	Schedule	Current Year	Previous Year
ASSETS			
PROPERTY,PLANT & EQUIPMENTS	8	70,19,88,788	68,07,41,660
INVESTMENTS FROM EARMARKED/ ENDOWMENT FUNDS	9	-	-
INVESTMENTS OTHERS	10	-	-
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	6,42,30,516	12,48,39,328
TOTAL		**76,62,19,304**	**80,55,80,988**
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:21055285AAAAEB4732
Place: Bhubaneswar
Date: The 13th Day of October 2021

GRC & Associates Bhubaneswar Chartered Accountants

For and on behalf of
Institute of Physics, Bubaneswar

(Mr. D. N. Sahoo)
Jr. Accounts Officer

(Mr. R. K. Rath)
Registrar
13/10/21

(Prof. K. K. Nanda)
Director
13/10/21

कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
भौतिकी संस्थान/INSTITUTE OF PHYSICS
रजिस्ट्रार/REGISTRAR
निदेशक/DIRECTOR

INSTITUTE OF PHYSICS

Sachivalaya Marg, Bhubaneswar

STATEMENT OF INCOME AND EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2021

(Amount in Rupees)

Particulars	Schedule	Current Year (2020-21)	Previous Year (2019-20)
INCOME			
Income from sale or services	12		
Grants/ Subsidies	13	26,66,00,000	36,68,00,000
Fees/ Subscriptions	14	0	0
Income from investments	15	0	0
Income from royalty, Publication etc	16	0	0
Interest Earned	17	16,279	5,15,577
Other Income	18	13,50,149	29,54,329
Increase decrease in stock of finised goods/ WIP	19	0	0
TOTAL (A)		**26,79,66,428**	**37,02,69,906**
EXPENDITURE			
Establishment Expenses	20	22,41,08,091	20,95,77,244
Other Administrative Expenses etc.	21	9,13,12,562	9,55,21,229
Expenditure on grants Subsidies etc (Plan grant Surrendered)	22	0	0
Interest Paid	23	0	0
Depreciation (Corresponding to Schedule 8)		5,47,90,802	8,81,57,211
TOTAL (B)		**37,02,11,454**	**39,32,55,684**
Balance being excess of Expenditure over Income (A-B)		(10,22,45,026)	(2,29,85,778)
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/ CAPITAL FUND		**(10,22,45,026)**	**(2,29,85,778)**
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 A Mohapatra
Partner
M.No. 055285
UDIN:21055285AAAAEB4732
Place: Bhubaneswar
Date: The 12th Day of October 2021

For and on behalf of
Institute of Physics, Bubaneswar

(Mr. D. N. Sahoo)
Jr. Accounts Officer

(Mr. R. K. Rath)
Registrar

(Prof. K. K. Nanda)
Director

कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
भौतिकी संस्थान/Institute of Physics
भुवनेश्वर/Bhubaneswar

रजिस्ट्रार/REGISTRAR
संस्थान/INSTITUTE OF Physics
भुवनेश्वर/BHUBANESWAR

निदेशक/DIRECTOR
संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2021

SCHEDULE 1 -CORPUS/CAPITAL FUND

(Amount in Rupees)

Particulars	Current Year (2020-21)		Previous Year (2019-20)	
Balances as at the beginning of the year		64,15,57,802		60,45,43,580
Add : Contributions towards Corpus/Capital Fund	4,06,02,095		6,00,00,000	
Add/(Deduct) : Balance of Income/(Expenditure) transferred from Income & expenditure Account	-10,22,45,026	-6,16,42,931	-2,29,85,778	3,70,14,222
Balances as at the year end		57,99,14,871		64,15,57,802

GRC & Associates Bhubaneswar Chartered Accountants

कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
भौतिकी संस्थान/Institute of Physics
भुवनेश्वर/Bhubaneswar

13/10/21
रजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

13/10/21
निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2021

SCHEDULE 3 - EARMARKED/ENDOWMENT FUNDS

(Amount in Rupees)

	Particulars	Current Year (2020-21)				Previous Year (2019-20)
		OB	Receipt	Payment	CB	
1	L. K. Panda Memorial Fellowship	2,20,901	12,697	1,00,000	1,33,597.82	2,20,901
2	TPSC Account	1,01,416.34	3,150	-	1,04,566.34	1,01,416
3	Inspire Grant of Dr. S.K.Agarwalla	2,792.00	91		2,883.00	2,792
4	Inspire Grant of Dr. Manimala Mitra	2,11,497.00	45,463	43,085	2,13,875.00	2,11,497
5	NPDF of Dr. P. Dutta	41,669.00	1,82,046	2,23,715	-	41,669
6	JC Bose Grant of Prof. A. M. Jayannavar	14,66,553.00	75,249	3,99,988	11,41,814.00	14,66,553
7	JC Bose Grant of Prof. S. M. Bhattacharjee	2,542.00	456	-	2,998.00	2,542
8	Ramanujan Fellowship Grant of Dr. A. K. Nayak	1,76,508.50	3,981	1,78,885	1,604.50	1,76,508
9	INSA Grant of Prof. J. Maharana	10,157.00	91,927	79,900	22,184.00	10,157
10	BI-IFCC Grant of Dr. P. K. Sahu	6,65,942.83	31,995	17,935	6,80,002.83	6,65,943
11	UGC-DAE CSR Grant	1,92,908.00	8,433	-	2,01,341.00	1,92,908
12	Woman Scientist Grant of Dr. S. Bandopadhyay	9,481.59	7,02,266	6,97,529	14,218.59	9,482
13	DST Grant of Prof. S. Varma	3,69,127.00	5,18,050	4,22,028	4,65,149.00	3,69,127
14	SERB Grant of Dr. D. Chaudhuri	12,69,854.00	53,849	4,68,612	8,55,091.00	12,69,854
15	Max-Plank Grant of Dr. D. Samal	17,99,488.62	32,92,039	3,30,894	47,60,633.62	17,99,489
16	CSIR Pool Scientist Programme	7,715.50	323	115	7,923.66	7,715
17	INSA Young Scientist - SK Agarwalla	2,41,069.00	5,09,198	3,32,559	4,17,708.00	2,41,069
18	NALCO Project - PV Satyam	12,45,443.70	25,196	12,67,885	2,754.70	12,45,444
19	KUNTALA BHATTACHARJEE MOBILITY FELLOWSHIP	23,97,640.00	27,56,701	29,16,141	22,38,200.00	23,97,640
20	Quantum Information Technologies .....-Prof. P Agarwal	4,90,356.00	16,48,940	2,70,180	18,69,116.00	4,90,356
21	PFMS	4,42,437.00	48,29,031	27,53,093	25,18,375.00	4,42,437
22	Swanajayanti Fellowship - Dr. S K Agarwalla	-	3,00,251	67,742	2,32,509.00	-
23	IOP-PJ-SERB Fellowship-Dr. Soumya C	-	9,73,433	4,76,034	4,97,399.00	-
24	IOP-PJ-SERB-Dr. Satyaprakash Sahoo	-	7,92,100	-	7,92,100.00	-
25	PJ-SERB of Dr. Debashis Choudhuri	-	2,24,654	1,90,069	34,585.00	-
26	INSPIRE Faculty Fellow of Dr. Aparajita Mandal		22,00,000	3,18,548	18,81,452.00	-
27	IOP DST Project of Dr. Shamik Banerjee	-	2,24,277	1,34,659	89,618.00	-
28	SERB Project of Dr. Dinesh Topwal	-	8,40,700	3,532	8,37,168.00	-
29	SERB Project of Dr. Kirtiman Ghosh	-	6,74,984	43,040	6,31,944.00	-
30	SERB Project of Dr. Debakanta Samal	-	22,75,818	81,000	21,94,818.00	-
TOTAL		1,13,65,499	2,32,97,298	1,18,17,168	2,28,45,629	1,13,65,499

GRC & Associates Bhubaneswar Chartered Accountants

Junior Accounts Officer

13/10/21
रजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

13/10/21
निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2021

SCHEDULE 7 -CURRENT LIABILITIES AND PROVISIONS:

(Amount in Rupees)

Particulars	Current Year (2020-21)		Previous Year (2019-20)	
A CURRENT LIABILITIES				
1 Statutory Liabilities:		6,43,694		15,55,417
Professional Tax Payable	200		30,650	
TDS Salary Payable	5,52,690		(2,240)	
TDS Non-Salary Payable	45,493		8,764	
Plan GST Payable	-		(7,212)	
GST Recovery Payable	45,161		35,916	
GSLI Premium Payable	150		150	
Interest Payable to DAE (NP)	-		4,05,287	
Interest Payable to DAE (Plan)	-		10,63,227	
IOPEWS Recovery Payable	-		8,475	
IPEA Recovery Payable	-		12,400	
2 Other Liabilities:		2,61,98,600		1,75,29,449
Earnest money Deposit	11,53,420		13,46,390	
Caution money from Scholars	15,000		13,600	
GSLI Claim Payable	41,707		42,699	
Project Grant Payable	8,29,240		17,67,000	
Provision for Expenses	2,31,36,977		1,23,38,674	
SSB Fellowship Payable	-		45,000	
Gratuity Payable	4,03,475		4,61,813	
Non-Plan Recovery Payable	-		3,200	
Security Deposit - contractors	6,18,781		15,11,073	
TOTAL(A)		**2,68,42,294**		**1,90,84,866**
B PROVISIONS		13,66,16,510		13,35,72,821
1 Gratuity	6,77,75,396		6,44,25,198	
2 Accumulated Leave Encashment	6,88,41,114		6,91,47,623	
3 Others (Specify)	0		0	
TOTAL(B)		**13,66,16,510**		**13,35,72,821**
TOTAL(A+B)		**16,34,58,804**		**15,26,57,687**

GRC & Associates Bhubaneswar Chartered Accountants

कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
भौतिकी संस्थान/Institute of Physics
भुवनेश्वर/Bhubaneswar

13/10/21
रजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

13/10/21
निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2021

SCHEDULE 8- PROPERTY,PLANT & EQUIPMENTS

(Amount in Rs.)

DESCRIPTION	Rate of Depreciation	GROSS BLOCK				Residual Value	DEPRECIATION				NET BLOCK	
		Cost/valuation As on 01.04.2020	Additions	Deduction	Cost/ valuation as on 31.03.2021		Opening Balance as on 01.04.2020	For the Year	On Deduction	Closing Balance as on 31.03.2021	As on 31.03.2021	As on 01.04.2020
A. PROPERTY,PLANT & EQUIPMENTS (PLAN):												
1 LAND:		-		-	-		-	-	-	-	-	-
a) Leasehold		50,00,000		-	50,00,000		-	-	-	-	50,00,000	50,00,000
2 BUILDINGS:		-		-	-		-	-	-	-	-	-
a) On leasehold Land	1.63%	21,09,86,379		-	21,09,86,379	1,05,49,319	5,36,80,613	34,39,078	-	5,71,19,691	15,38,66,688	15,73,05,766
3 ROADS	1.90%	65,48,158		-	65,48,158	3,27,408	62,20,750	-	-	62,20,750	3,27,408	3,27,408
4 PLANT MACHINERY & EQUIPMENT	5.28%	89,88,49,782	14,91,981	-	90,03,41,763	4,50,17,088	45,54,49,163	4,75,38,045	-	50,29,87,208	39,73,54,555	44,34,00,619
5 COMPUTER/PERIPHERALS	16.21%	14,96,88,074	14,90,239	-	15,11,78,313	75,58,916	14,22,03,670	2,41,568	-	14,24,45,238	87,33,075	74,84,404
6 Capital Work In Progress		-	7,20,48,124	-	7,20,48,124	7,20,48,124	-	-	-	-	7,20,48,124	-
7 Advance for capital Goods			2,28,702		2,28,702	2,28,702	-			-	2,28,702	-
TOTAL(A)		1,27,10,72,394	7,52,59,046	-	1,34,63,31,440	13,57,29,557	65,75,54,196	5,12,18,691	-	70,87,72,887	63,75,58,552	61,35,18,197
B. PROPERTY,PLANT & EQUIPMENTS (NON-PLAN)												
1 VEHICLES	9.50%	28,70,817	-	-	28,70,817	1,43,541	24,77,593	2,72,728	-	27,50,321	1,20,496	3,93,224
2 FURNITURE, FIXTURES	9.50%	2,34,22,316	-	-	2,34,22,316	11,71,116	2,22,51,200		-	2,22,51,200	11,71,116	11,71,116
3 OFFICE EQUIPMENT	9.50%	12,94,54,865	6,31,265	-	13,00,86,130	65,04,307	12,29,82,122	59,970	-	12,30,42,092	70,44,038	64,72,743
4 ELECTRIC INSTALLATIONS	6.33%	5,09,20,593	-	-	5,09,20,593	25,46,030	1,49,62,809	32,23,274	-	1,81,86,083	3,27,34,510	3,59,57,784
5 LIBRARY BOOKS	9.50%	46,45,71,913	1,69,880	24,598	46,47,17,195	2,32,35,860	44,13,43,317	16,139	2,337	44,13,57,119	2,33,60,076	2,32,28,596
TOTAL(B)		67,12,40,504	8,01,145	24,598	67,20,17,051	3,36,00,854	60,40,17,041	35,72,111	2,337	60,75,86,815	6,44,30,236	6,72,23,463
TOTAL OF CURRENT YEAR (A+B)		**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**
PREVIOUS YEAR		**1,91,30,29,893**	**2,92,83,004**	-	**1,94,23,12,897**	**9,68,65,646**	**1,17,34,14,026**	**8,81,57,211**	-	**1,26,15,71,237**	**68,07,41,660**	**73,96,15,867**

GRC & Associates Bhubaneswar Chartered Accountants

कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
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रजिस्ट्रार/REGISTRAR 13/10/21
भौतिकी संस्थान/INSTITUTE OF PHYSICS
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भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2021

SCHEDULE 11-CURRENT ASSETS, LOANS, ADVANCES ETC.

(Amount in Rupees)

Particulars	Current Year (2020-21)		Previous Year (2019-20)	
A CURRENT ASSETS:				
1 Inventories:		22,89,707		28,39,437
a) Electrical Fittings Stock	13,65,212		13,43,264	
b) Office Stationery	1,35,998		2,72,932	
c) Computer Stationery	3,00,544		6,13,440	
d) Cleaning Material Stock	25,323		-	
e) Diesel Stock	1,08,752		99,631	
f) Carpentry Material Stock	1,04,570		52,104	
g) Workshop Spares	1,82,986		3,37,443	
h) PH Material Stock	66,322		1,20,623	
2 Cash balances in hand (including cheques/ drafts and imprest)				
3 Bank Balances:		5,87,81,442		11,60,54,796
a) With Scheduled Banks:				
i) In current accounts SBI	1,69,11,601		5,71,20,097	
b) Savings accounts				
i) IOB CS Pur (SB-10917)	3,88,951		3,77,13,071	
ii) IOB CS Pur (SB-16916)	1,73,24,514		91,68,749	
iii) UBI CS Pur (SB-316)	6,84,944		6,64,385	
iv) UBI CS Pur (SB-14746)	23,709		22,995	
v) IOP Corpus Fund (SB-19339)	6,02,095		-	
vi) Project Bank Account (Sch.3)	2,28,45,629		1,13,65,499	
TOTAL(A)		**6,10,71,149**		**11,88,94,233**
B LOANS, ADVANCES AND OTHER ASSETS				
1 Loans (Interest bearing):		65,562		60,150
a) Computer Advance	65,562		60,150	
2 Interest Accrued but not due on Loans		33,221		1,02,940
a) Motor Car Advance	-		55,714	
b) House Buildings Advance	28,243		40,351	
c) Computer Advance	4,978		6,875	
3 Loans (Non-Interest bearing):		4,12,714		2,64,944
a) Staff Advance	10,714		1,22,444	
b) Festival Advance	3,36,000		-	
c) Travel Advance	66,000		1,42,500	
4 Advances and other amounts recoverable in cash or in kind or for value to be received:		26,47,870		55,17,061
a) On Capital Account				
b) Prepayments	-		96,061	
c) Security deposit With CESCO	26,21,944		26,21,944	
d) Franking machine deposit	2,976		46,273	
e) Security Deposit with BSNL	2,000		2,000	
f) Security Deposit for GAS	20,950		20,950	
g) STDR against LC	-		27,29,833	
TOTAL(B)		**31,59,367**		**59,45,095**
TOTAL(A+B)		**6,42,30,516**		**12,48,39,328**

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REGISTRAR 13/10/21
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INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2021

SCHEDULE 13 -GRANTS/ SUBSIDIES

(Amount in Rupees)

Particulars	Current Year (2020-21)		Previous Year (2019-20)	
1 DAE - Government of India		26,66,00,000		36,68,00,000
a) Non-Plan (Salary)	17,69,00,000		26,46,00,000	
b) Non-Plan (General)	8,97,00,000		10,22,00,000	
2 Government Of Orissa (Non-Plan Revenue)		-		-
TOTAL		**26,66,00,000**		**36,68,00,000**

INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2021

SCHEDULE 17 - INTEREST EARNED

(Amount in Rupees)

Particulars	Current Year (2020-21)		Previous Year (2019-20)	
1 On Term Deposits:		-		3,44,007
a) With Scheduled Banks				
b) Others (LC & Security Deposit)	-		3,44,007	
2 On Savings Accounts:		-		-
a) With Scheduled Banks				
3 On Loans:		16,279		1,71,570
a) Computer Advance	16,279		30,940	
b) Motor Car Advance	-		1,39,288	
c) Pending Advance	-		1,342	
TOTAL		**16,279**		**5,15,577**

GRC & Associates Bhubaneswar Chartered Accountants

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INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2021

SCHEDULE 18- OTHER INCOME

(Amount in Rupees)

Particulars	Current Year (2020-21)		Previous Year (2019-20)	
Other Income				
1 Miscellaneous Income		9,026		11,35,534
a) Project Overhead	-		10,53,980	
b) I-Card Charge	66		454	
c) RTI Fee	10		100	
d) Auditorium Charges	-		73,000	
e) Miscellaneous Income	8,950		8,000	
2 Sale of Tender paper		11,000		7,000
3 Rent				18,11,795
a) Bank Rent	3,60,000	13,30,123	3,60,000	
b) Guest House Rent	1,26,370		7,17,875	
c) Licence Fee	8,43,753		7,33,920	
TOTAL		**13,50,149**		**29,54,329**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2021

SCHEDULE 20 - ESTABLISHMENT EXPENSES

(Amount in Rupees)

Particulars	Current Year (2020-21)		Previous Year (2019-20)	
1 Salaries and Wages		14,42,92,679		13,04,01,288
a) Staff Salary	11,80,64,615		10,41,86,862	
b) NPS Contribution	53,08,199		42,24,839	
c) Honorarium	2,87,096		8,77,729	
d) Fellowship	2,03,97,769		2,07,26,858	
e) Remuneration to Medical Officer	2,35,000		3,85,000	
2 Allowances and Bonus		1,11,83,284		90,75,286
a) PRIS	89,14,534		90,59,395	
b) Update Allowance	22,62,868		-	
c) Overtime Allowance	5,882		15,891	
3 Staff Welfare Expenses		47,13,584		44,63,059
a) Reimbursement of Medical Expenses	30,47,588		39,59,291	
b) Canteen Expense	5,590		-	
c) Recreation & Welfare Expenses	89,411		5,01,194	
d) Children Education Allowance	15,66,000		-	
e) Medical Aid Centre Expenses	4,995		2,574	
4 Retirement and Terminal Benefits		6,25,03,807		6,38,00,694
a) Leave salary	54,28,231		86,11,833	
b) Pension	4,87,74,816		5,34,54,346	
c) Gratuity	83,00,760		17,34,515	
5 Others		14,14,737		18,36,917
a) Contigency Grant to Scholars	14,14,737		18,36,917	
TOTAL		**22,41,08,091**		**20,95,77,244**

GRC & Associates Bhubaneswar Chartered Accountants

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INSTITUTE OF PHYSICS, BHUBANESWAR
SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2021

SCHEDULE 21 -OTHER ADMINISTRATIVE EXPENSES ETC.

(Amount in Rupees)

Particulars	Current Year (2020-21)		Previous Year (2019-20)	
1 Repair & Maintenance		2,33,19,898		2,45,20,436
a) Civil	64,91,706		1,01,65,656	
b) Vehicle	1,84,018		3,93,910	
c) Library	7,76,131		5,99,376	
d) Workshop	1,81,239		1,19,301	
e) Furniture	-		2,01,211	
f) Electrical	5,74,826		12,26,856	
g) AC Plant	51,58,714		44,41,658	
h) Computer	49,84,795		36,22,786	
i) Laboratory	44,79,486		32,23,259	
j) Garden	93,822		62,637	
k) Telephone	70,328		78,682	
l) Office Equipment	3,24,833		3,85,104	
2 Electricity and power		2,08,60,455		2,14,98,926
3 Water charges		3,98,753		3,19,388
4 Conference & Symposia		1,169		5,36,263
5 Science Outreach Activities		6,163		4,30,571
6 Postage & Telegram		65,426		68,220
7 Telephone & Telex		5,19,799		5,58,178
8 Printing and Stationery		6,81,621		9,74,109
9 Travelling Expenses		21,81,086		31,24,009
a) Conference TA	1,21,458		3,54,171	
b) Foreign Travel	-		4,19,428	
c) Visiting scientist TA	1,00,215		1,87,888	
d) Domestic Travel	3,94,972		15,33,176	
e) Leave Travel concession	15,64,441		6,14,918	
f) Hire Charge	-		14,428	
10 Auditors Remuneration		1,18,000		-
11 Entertainment Expenses		86,442		2,21,444
12 Security Charges		59,75,185		56,61,545
13 Professional Charges		89,550		2,28,620
14 Project Revenue Expenses		5,67,593		27,27,373
a) ALICE Utilisation and CBM Participation	1,40,152		5,08,035	
b) Development of Computing and Network Facilities	88,115		7,97,840	
c) Strengthening Low Energy Accelerator	-		722	
d) Vigyan Prativa	3,39,326		7,65,271	
e) Infrastructure and Housing	-		6,55,505	
15 Advertisement and Publicity		6,07,342		6,93,758
16 Books & Journal		3,56,56,551		3,38,07,501
a) Books	-		4,000	
b) Online Journal Subscription	3,56,56,551		3,38,03,501	
17 Lease Rent	3,676	3,676		
18 Others		1,73,852		1,50,888
a) Miscellaneous Expenses	73,416		1,50,888	
b) JEST Expenses	78,175		-	
c) Writing off books	22,261		-	
TOTAL		9,13,12,562		9,55,21,229

GRC & Associates Bhubaneswar Chartered Accountants

Accounts Officer
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INSTITUTE OF PHYSICS, BHUBANESWAR
STATEMENT OF RECEIPTS & PAYMENTS FOR THE FINANCIAL YEAR 2020-21

(Amount in Rupees)

RECEIPTS	SCH	Current Year 2020-21	Previous Year 2019-20	PAYMENTS	SCH	Current Year 2020-21	Previous Year 2019-20
I. **Opening Balances**				I. **Expenses**			
a) Cash in hand		-	1,976	a) Establishment Expenses (Corresponding to Sch 20)	C	19,89,25,849	25,05,33,752
b) Bank balances				b) Administrative Expenses (Corresponding to Sch 21)	D	8,28,69,583	9,59,65,856
i) In current accounts SBI		5,71,20,097	26,96,235	II. **Payments made against funds for various projects**		1,18,17,168	1,13,94,429
ii) In Savings accounts				III. **Investments and deposits made**			
Indian Overseas Bank (NP)		3,77,13,071	1,86,14,872	a) Out of Earmarked/Endowment funds			-
Indian Overseas Bank (Plan)		91,68,749	32,01,028	b) Out of Own Funds (Investments-Others)			-
Union Bank (NP)		6,64,385	62,618	IV. **Expenditure on Fixed Assets & Capital W.I.P**			
Union Bank (Plan)		22,995	22,229	a) Purchase of Fixed Assets	E	6,62,791	1,00,14,844
Project Bank Account		1,13,65,499	90,84,957	b) Expenditure on Work-in-Progress		7,22,76,826	-
II. **Grants Received**				V. **Refund of surplus money/Loans**			
a) From Govt. of India - Plan		4,00,00,000	6,00,00,000	a) To the Government of India			-
Non-Plan		26,66,00,000	36,68,00,000	b) To the State Government			-
b) From State Government			-	c) To other providers of funds			-
c) Corpus Fund		6,02,095					
III. **Receipt from Sponsored Project**		2,32,97,298	1,36,74,971	VI. **Finance Charges (Interest)**			-
IV. **Interest Received**				VII. **Other Payments**			
a) On Bank deposits			-	Project Revenue Expenses	F	4,26,607	27,27,373
b) Loans, Advances etc.	A	11,301	4,70,171	Staff Advances	G	6,30,061	-
V. **Other Income**				VIII. **Closing Balance**			
Misc Receipts		3,18,290	11,35,534	a) Cash in hand			-
Sale of Tender paper		11,000	7,000	b) Bank balances			
House/Guest House Rent		2,45,482	18,08,195	i) In current accounts SBI		1,69,11,601	5,71,20,097
Sale of Asset			-	ii) Savings accounts			
VI. **Amount Borrowed**			-	Indian Overseas Bank (NP)		3,88,951	3,77,13,071
VII. **Any Other Receipts**				Indian Overseas Bank (Plan)		1,73,24,514	91,68,749
Earnest Money Deposit		(1,92,970)	(8,84,140)	Union Bank (NP)		6,84,944	6,64,385
Security Deposit			(1,37,009)	Union Bank (Plan)		23,709	22,995
Caution Money		1,400	1,600	IOB Corpus Fund A/c_19339		6,02,095	-
Recoveries / Current Dues	B	(2,05,58,366)	1,01,30,813	Project Bank Account		2,28,45,629	1,13,65,499
TOTAL		**42,63,90,326**	**48,66,91,050**	**TOTAL**		**42,63,90,326**	**48,66,91,050**

GRC & Associates, Bhubaneswar, Chartered Accountants

13/10/21

13/10/21

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2021

(Amount Rs)

	Current Year	Previous Year
SCHEDULE A - INTEREST ON LOANS & ADVANCES		
Interest on House Building Advance	-	12,108
Interest on Motor Car Advance	-	83,574
Interest on Computer Advance	11,301	29,140
Interest on Pending Advance	-	1,342
Interest on Security Deposit	-	3,44,007
Total	**11,301**	**4,70,171**
SCHEDULE B - RECOVERIES & CURRENT DUES		
Advance For Motor Car	-	2,000
Advance For Computer	-	93,550
CHSS Contribution Recovery	4,59,698	15,96,582
Deputed Staff Recovery Payable		(32,090)
Gratuity Payable	(6,41,715)	1,74,690
GSLI Premium Payable	(42,300)	-
Interest Payable to DAE (NP)	(4,05,287)	38,346
Interest Payable to DAE (Plan)	(10,63,227)	(5,43,112)
IOPEWS Recovery Payable	(75,813)	8,475
IPEA Recovery Payable	(24,400)	12,400
Non-Plan Recovery Payable		-
GSLI Claim Payable	(992)	14,476
NPS Recovery Payable	(42,85,444)	(26,013)
SSB Award Fellowship Payable	10,269	-
Plan Professional Tax Payable	(1,125)	325
Plan Security Deposit Payable	(5,84,280)	36,278
Professional Tax Payable	(2,85,025)	30,650
Project Grant Payable	(9,37,760)	(32,33,000)
Provision for Expenses	(1,23,38,674)	1,23,38,674
GST Recovery Payable	(1,99,901)	(1,15,999)
Plan GST Payable	(66,139)	(58,662)
Plan TDS Payable		(43,190)
TDS Non-Salary Payable	(1,99,939)	(4,824)
TDS Salary Payable	4,16,260	(69,730)
WCT Recovery Payable		(89,013)
PM CARES Contribution Payable	(2,92,572)	-
Total	**(2,05,58,366)**	**1,01,30,813**

GRC & Associates Bhubaneswar Chartered Accountants

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भुवनेश्वर/Bhubaneswar

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भुवनेश्वर/BHUBANESWAR

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2021

(Amount Rs)

	Current Year	Previous Year
SCHEDULE C - Establishment Expenses		
Salary	10,48,69,993	11,43,77,765
NPS	48,97,996	44,82,436
PRIS	89,14,534	1,85,40,425
Update Allowance	18,70,918	23,81,253
Leave Salary	47,65,178	97,83,969
Book Grant & Contigency	14,14,737	18,36,917
Entertainment	91,442	2,21,444
Honorarium	2,27,836	9,40,129
Overtime Allowance	5,882	15,891
Children Education Allowance	15,66,000	16,94,250
Pension	4,24,96,634	5,61,94,065
Pre Doctoral Fellowship	15,64,617	44,18,720
Doctoral Fellowship	1,38,80,235	1,28,61,873
Post Doctoral Fellowship	27,80,235	48,79,530
SSB Award Fellowship	55,269	(30,000)
Recreation Club Expenses	83,181	5,07,424
Reimbursement of Medicine	45,41,696	56,76,468
Remuneration Medical Officer	1,70,000	4,20,000
Medical Aid Centre Expenses	14,885	2,574
Visiting Scientist TA	1,00,215	1,84,288
Leave Travel Concession	2,72,725	6,14,918
Gtatuity	43,41,641	1,05,29,413
Total	**19,89,25,849**	**25,05,33,752**
SCHEDULE D - Administrative Expenses		
Administrative		
Advertisement	5,93,415	9,37,591
Audit Fees	54,000	59,000
Conferene & Symposia	1,169	5,36,263
Science Outreach activities	6,163	4,30,571
Electricity Charges	1,96,34,690	2,34,87,056
Books	1,69,880	4,000
Library & Journals	3,56,56,551	3,38,03,501
Miscellaneous Expenses	73,416	1,50,888
Postage & Telegraph	(2,551)	85,016
Printing Stationey	5,34,083	9,28,230
Security Services	54,82,283	61,14,412
Foreign Travel Expenses	-	2,99,428
Domestic Travel Expenses	3,59,951	15,63,676
Confernce TA	1,21,458	3,54,171
Telephone & Telex	4,82,294	6,34,205
Water Charges	3,48,544	3,46,098
Hire Charge	-	14,428
JEST Expenses	76,850	-
Professional Charges	82,635	2,28,620

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2021

(Amount Rs)

	Current Year	Previous Year
SCHEDULE D - Administrative Expenses (Contd....)		
Maintenance		
Computer Maintenance	43,47,868	41,99,463
Laboratory Maintenance	28,79,599	32,63,259
Civil Maintenance	55,80,033	1,06,50,628
Office Equipment Maintenance	2,50,696	3,95,010
Furniture Maintenance	-	2,01,211
Library Maintenance	7,31,704	6,23,376
AC Plant Maintenance	45,82,657	48,02,658
Garden Maintenance	88,822	65,157
Electrical Maintenance	4,84,193	12,41,461
Telephone Maintenance	69,762	78,682
Workshop Maintenance	21,782	59,142
Vehicle Maintenance	1,57,045	4,08,655
Canteen and Guest House	590	-
Total	**8,28,69,583**	**9,59,65,856**
SCHEDULE E - PURCHASE OF FIXED ASSETS		
NON-PLAN		
Office Equipment	6,09,175	99,276
Furnitue & Fixtures		27,854
Telephone Equipment		3,850
Computer Equipment	12,200	33,350
Laboratory Equipment		13,54,736
PLAN		
Development of Computing & Network Facilities	13,13,668	15,19,754
Strengthening Low Energy Accelerator	(12,72,252)	69,76,024
Total	**6,62,791**	**1,00,14,844**
SCHEDULE F - PROJECT REVENUE EXPENSES		
PLAN		
ALICE Utilization and CBM participation Expenses	28,152	5,08,035
Development of Computing & Network Facilities Expenses	85,129	7,97,840
Strengthening Low Energy Accelerator Expenses	-	722
Infrastructure Expenses	-	6,55,505
Vigyana Pratibha Expenses	3,13,326	7,65,271
Total	**4,26,607**	**27,27,373**
SCHEDULE G - STAFF ADVANCES		
Advance For Computer	84,540	-
Advance for Domestic Travel	4,521	-
Advance for Festival	4,20,000	-
Advance for LTC	96,000	-
Advance for Vigyan Pratibha	25,000	-
Total	**6,30,061**	**-**

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13/10/21

13/10/21

INSTITUTE OF PHYSICS
BHUBANESWAR

SCHEDULES FORMING PART OF THE ACCOUNTS

FOR THE YEAR ENDED ON 31.03.2021

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 the total land of Ac. 56.130 dec. acquired, the institute is in possession of Ac.6.130 dec. leasehold land. The Lease rent has been paid upto 31.03.2019 and provided up to 31.03.2021. Rest of the land is in the name of Higher Education Department, Govt. of Odisha, alienated in favour of the Institute and 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 investment in shape of STDR with bank against Letter of Credits.

4. **INVENTORY VALUATION**

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 ₹ 2.28 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, 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.

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 31.03.2021 has been provided in accounts on actual valuation. Provision for liability towards accumulated leave encashment benefit to the employees as on 31.03.2021 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 yet been created by the Institute.

9.4 Contribution to newly defined pension scheme have 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 31.03.2021 has been audited by a firm of Chartered Accountants.

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INSTITUTE OF PHYSICS
BHUBANESWAR

SCHEDULES FORMING PART OF THE ACCOUNTS

FOR THE YEAR ENDED ON 31.03.2021

SCHEDULE 25 – CONTIGENT LIABILITIES AND NOTES ON ACCOUNTS

1. CONTIGENT LIABILITIES

1.1.	Claims against the Institute not acknowledged as debt Note: Income Tax Department raised demand of Rs. 5,73,436.00 during the Assessment Year 2017-18 against which the institute has gone in appeal. However, pending appeal before CIT (A) the department has adjusted the refund amounting to Rs. 201704.00 for the assessment year 2019-20 against the above demand.	3,71,732
1.2.	Bank Guarantee given by / on behalf of the Institute	NIL
1.3.	Bills discounted with Bank	NIL
1.4.	Letter of Credit opened by bank on behalf of the Institute outstanding as on 31.03.2021 against 110% margin money	720,48,124
1.5.	Disputed demand in respect of Income Tax as on 31.03.2021 Sales Tax (IDS) Municipal Taxes	 NIL NIL NIL
1.6.	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

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rounded off to nearest rupee.

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

2.7. STDR Against LC of Rs. 720,48,124/- includes the following:

Date of Payment	Head of A/c	Party Name	Item Name	Amount (Rs.)
22.01.2021	Investigating the spin structure	M/s Thermal Technology LLC, USA	Direct Current Heating/Spark Plasma Sintering Furnace	199,92,920
-do-	-do-	M/s Shimadzu Asia Pacific Pte. Ltd. Sinapore	X-Ray Photoelectron Spectrometer (XPS) System	520,55,204

2.8. 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.

2.9. Schedule 1 to 25 are annexed to and form an integral part of the Balance Sheet as at 31.03.2021 and Income & Expenditure Account for the year ended on that date.

3 FOREIGN CURRENCY TRANSACTIONS

Value of Imports calculated on C.I.F/Ex-works & FOB basis	31.03.2021 (₹)	31.03.2020 (₹)
a) Purchase of Lab. Equipment	16,24,500	2,41,06,916
b) Stores, Spares and Consumables	1,54,074	6,61,483
c) Journal subscription	3,21,87,370	2,52,42,903
Expenditure in foreign currency		
a) Travel	Nil	Nil
b) Other expenditure (Honorarium)	Nil	Nil
Earnings		
Value of Exports on FOB basis	Nil	Nil

4 Remuneration to Auditors

As Auditors	59,000	59,000

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ACTION TAKEN REPORT ON THE COMMENTS OF STATUTORY AUDITORS ON THE ANNUAL ACCOUNTS OF INSTITUTE OF PHYSICS, BHUBANESWAR FOR THE FINANCIAL YEAR 2020-21

Sl. No.	AUDITOR'S OBSERVATION	INSTITUTE'S REPLY
Qualified opinion		
Basis of qualification		
1	a) The Society has not followed AS 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 charges 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.
	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.
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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