Annual Report
&
Audited Statement of Accounts
2019-20

राष्ट्र की सेवा में परमाणु
भौ सं
IOP
ATOMS IN THE SERVICE OF THE NATION
भौतिकी संस्थान
Institute of Physics

Institute of Physics
Bhubaneswar

Annual Report

and

Audited Statement of Accounts

2019-20

Institute of Physics

Bhubaneswar

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About the Institute

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

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

The Institute offers Ph.D. programme to the scholars who successfully complete the one year pre-doctoral course at the Institute. The selection for the pre-doctoral programme is through the Joint Entrance Screening Test (JEST). Candidates qualifying the CSIR-UGC NET examination and those having high GATE scores are also eligible for an entry to the pre-doctoral program. The Ph.D. degree is being awarded by Homi Bhaba National Institute (HBNI), Mumbai on successful completion of the programme.

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.

CHAIRMAN AND MEMBERS OF THE GOVERNING COUNCIL FOR THE YEAR 2019-20

Dr. K. N. Vyas, Chairman (AEC) and Secretary (DAE) Department of Atomic Energy, Anushakti Bhavan, C.S.M. Marg, Mumbai-400001	:	Chairman
Dr. S. M. Yusuf, Director, Institute of Physics, Bhubaneswar (since 23.01.2020)	:	Member
Prof. Sudhakar Panda, Director, Institute of Physics, Bhubaneswar-751005 (until 22.01.2020)	:	Member
Prof. Pinaki Majumdar, Director Harish-Chandra Research Institute Chhatnag Road, Jhunsi, Allahabad-211019	:	Member
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Shri Bhaskar Jyoti Sharma, IAS (until 08.08.2019) Commissioner-cum-Secretary, Science & Technology Department Government of Odisha, Bhubaneswar-751001	:	Member
Prof. Surya Narayan Nayak, PG Department of Physics, Sambalpur University Jyoti Vihar, Burla, Sambalpur-768019	:	Member
Prof. Sukanta Kumar Tripathy, P. G. Department of Physics Berhampur University, Bhanja Vihar, 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 very happy to present the Annual Report and the Audited Statement of Accounts of Institute of Physics (IOP), Bhubaneswar for the year 2019-20. I would like to record my special thanks to all the faculty members, research scholars, staff members and well-wishers of IOP community for their full co-operation.

This Annual Report showcases our activities in academics, research and teaching, presenting the achievements and accomplishments of IOP members. IOP is an autonomous premier research institute under the Department of Atomic Energy, Government of India. Scientists here are involved in front line research in experimental as well as theoretical physics namely, theoretical high energy physics, theoretical condensed matter physics, theoretical nuclear physics, experimental condensed matter physics, experimental high energy physics, and quantum information.

Reflecting the high quality of research activities in applied and fundamental physics, this year IOP members have published 132 papers in high standard international peer–reviewed journals. Out of 132 publications, 22 papers have been published in journals having impact factor (IF) more than 5, viz., Adv. Materials (IF>27), Nature Physics (IF>16), Nature Communications (IF>11), *etc*. A large number of seminars, colloquia, and workshops were organized by the Institute in important frontier areas of Physics. Institute members actively interact, and are involved in collaborative research, with scientists of many national and international institutes. During this year, IOP members have delivered 52 invited lectures/ colloquia/ seminars and 14 popular level science talks. Reputed visiting scientists, from India and abroad, delivered 64 seminars, colloquia, advanced lectures, and public talks. One of the high energy physics group members, Prof. Sanjib Kumar Agarwalla has won the prestigious B. M. Birla Science Prize in Physics for the year 2018 (awarded in 2019).

Institute has a strong outreach program for communicating science and scientific temper to school and college students, teachers, and public in general. Our members enthusiastically celebrate National Science Day and open house days by delivering popular level scientific talks, and explaining the principles and utilities of the advanced experimental lab facilities to visiting students and teachers. Activities like optical telescope viewing of the night sky are also held for students and public on various occasions. The Institute observed the 45th Foundation Day on 4th September 2019 in which Professor Ashok Kumar Das, Eminent Physicist, Ex-BARC, and Former Vice Chancellor Utkal University, and Vice-Chairperson State Higher Education Council, Odisha, graced the occasion as the Chief Guest. Among other activities, IOP has been awarded by DAE for excellent work in Hindi. During the year, IOP Library has also successfully implemented RFID based "Smart Library Solution" through the KOHA Integrated Library Management System (ILMS).

These are difficult times, with the ongoing Covid-19 pandemic. I am confident that the Institute members will work efficiently, with care, and will be able to successfully navigate through these challenging times.

I would like to express my sincere appreciation for the support and encouragement that we have received from all the stake holders associated with IOP including the Governing Council. I would also like to acknowledge the efforts of the members who have worked very hard to bring out this Annual Report.

Md. Yusuf

Professor S. M. Yusuf
Director, IOP

Contribution of Institute of Physics (IOP) towards DAE Vision

Being a premier research institution under DAE, IOP has been contributing immensely to the DAE's involvement in basic and applied research in the frontier areas of Physics. The institute has many internationally acclaimed leading groups involved in vibrant research in the fields of theoretical high energy physics and string theory, theoretical nuclear physics, ultra-relativistic heavy-ion collisions and cosmology, quantum information, experimental high energy physics and theoretical and experimental condensed matter physics. Further, it 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. IOP has a large number of advanced research facilities including a 3MV Pelletron particle accelerator which is used yearly by around 80 groups from various institutes, IITs and Universities. Many of these facilities are used for the applied research in the currently hot and exotic material systems like, quantum materials, solar materials, nano-systemsetc.

IOP has also a very active outreach programme, in line with the DAE vision, introducing atomic energy for the betterment of society. As part of this program lots of activities are being undertaken covering school and college students. The institute is also involved the popularization of AKRUTI introduced by DAE to disseminate the BARC technologies in the field of technology, agriculture and industry.

Brief Summary of Annual Report 2019-2020

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

At IOP the broad areas of research in theoretical high energy physics are string theory, high energy physics phenomenology, and cosmology. String theory research focuses mainly on properties of black holes, holographic correspondence in AdS and asymptotically flat space, applications of AdS-CFT duality to strongly coupled gauge theories and interface between quantum information theory and string theory. The activities of the high energy physics phenomenology have a special emphasis on collider physics, neutrino physics, dark matter, astroparticle physics and physics beyond the standard model. A significant part of the research is aimed towards exploring the physics potential of various ongoing and upcoming experiments in particle physics like LHC, the proposed 100 TeV collider, CLIC, ILC, India-based Neutrino Observatory (INO), DUNE and Hyper-Kamiokande. The group is also active in the field of quark-gluon plasma, cosmology and astroparticle physics. In this area, the main focus is simulation of the quark-gluon phase transition and magnetohydrodynamics to understand the flow of the plasma. The group members are also studying the emerging issues in astroparticle physics like dark matter, dark energy, baryogenesis and properties and detection of gravitational waves. Very recently, one of the HEP group members, Prof. Sanjib Kumar Agarwallahas won the prestigious B. M. Birla Science Prize in Physics for the year 2018. (delared in 2019)

The condensed matter theory group at IOP is actively involved in pursuing research with the main focus in 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 interplay of strong correlation and topology in artificial lattice systems. The group members have investigated impact of strong correlation and periodic drive in topological band properties of different lattice systems, Floquet engineering of higher-order Topological insulators,transport properties of driven semi-Dirac materials, unusual spin-wave spectrum for helical spin configuration for the α-MnO_2 materials, an absence of order by disorder attributed to newly found macroscopic conserved quantity and abelian anion excitations in H_2SQ materials etc.

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 the 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 nanosystems. 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. Different users (both internal and external) and research scholars are using this facility for their research. During this period the accelerator facility has catered several users from the Institute of Chemical Technology-Indian Oil Bhubaneswar, Indraprastha University-New Delhi, SOA University-Bhubaneswar, UGC-DAE Kolkata Centre, NISER, Bhubaneswar. Other important 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.Recently, one of the group members Prof. TapobrataSom, has published a paper in the prestigious journal "Advanced Materials" (IF: 25). Also, one of the group members, Prof. Debakanta Samal organized a national conference on "Quantum Matter Heterostructure (QMH)" from February 17-19, 2020.

Among other activities, IOP has been awarded by DAE for excellent work in Hindi. A scientific seminar was organized on the title of "Atomic Energy and Environment" in Hindi on 23rd August 2019. IOP also takes part in the climate change issue and regarding this, a joint scientific seminar on "Role of scientific and Technical Institutes on the eradication of the effect of Climate Change" held on 10.01.2020. Regarding "Swachh Bharat Abhiyan" (SBA), IOP has conducted one full month activity inside the campus as well as nearby localities. IOP organized "Science Day – a mega activity" in the month of February 2020. During the year, IOP Library has also successfully implemented RFID based "Smart Library Solution" through the KOHA Integrated Library Management System (ILMS).

ACADEMIC PROGRAMMES

1.1 PRE-DOCTORAL PROGRAM

One of the most important objectives of the Institute is to train and guide young scholars to do research in physics. Since 1975, IoP has a regular Pre-doctoral (Post M.Sc.) course,which is a very important academic program because it is designed to train the M.Sc. students for carrying out research activities. Thisprogramme is aimed at imparting a broad based training in advanced physics and research methodology to students. The course work is planned with the view that it should help the students not only in doctoral research, but also enable him/her to become a good physics teacher.The Institute participates in conducting the Joint Entrance Screening Test (JEST) to select students who are interested in pursuing Ph.D. in physics. The final selection of a student is based on the result of written test and an interview conducted at the institute. This year the Pre-doctoral course began in August, 2019. Utkal, Berhampur and Sambalpur Universities have recognized our Pre-doctoral program equivalent to their M.Phil degrees. On completion of the Pre-doctoral program, students are eligible to join research under the supervision of faculty members of the Institute, leading to the Ph.D. degree awarded by HomiBhabha National Institute (HBNI).

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

Students were called for written test and interview for admission to the predoctoral course in May, 2019. This includes JEST qualifiers, UGC-CSIR qualifiers and valid GATE score holders. Following students enrolled to the doctoral course work program for the year 2019-2020:

1. Mr. Ithineni Sairam
2. Mr. Rameswar Sahu
3. Mr. Sanu Varghese
4. Mr. Sheikh Moonsun Pervez
5. Mr. Subhadip Bisal
6. Mr. Debasish Mondal
7. Mr. Dipak Maity
8. Mr. Digbijaya Palai

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

Semester – I

Advanced Quantum Mechanics	:	Dr. Kirtiman Ghosh
Advanced Statistical Mechanics	:	Dr. ArijitSaha
Quantum Field Theory – I	:	Dr. Debottam Das
Advanced Experimental Techniques	:	Dr. DebakantaSamal
Experimental Physics Lab	:	Dr. Dinesh Topwal

Semester – II

Numerical Methods Mathematical Methods and Research Methodology	:	Dr. Shamik Banerjee
Special Topics inCondensed Matter Physics	:	Dr. Saptarshi Mandal
Special Topics in High Energy Physics	:	Dr. Arun Kumar Nayak
High Energy Physics	:	Assoc.Prof. Sanjib Kumar Agarwalla
Special Topics in Statistical Physics	:	Prof. S. Mukherji

As a part of the course work, students also worked on projects in the last Semester under supervision of faculty members of the institute. Titles of the projects undertaken by student during 2019-2020 are given below along with the name of the supervisor.

Name of Supervisor	Name of Student	Title of Project
Dr. A. Saha	Mr. IthineniSairam	First order topological insulators
Dr. K. Ghosh	Mr. RameswarSahu	Standard Model and running of gauge couplings
Dr. A. K. Nayak	Mr. Sanu Varghese	Machine learning techniques in high energy physics
Dr. S. Mandal	Mr. Sheikh Moonsun Pervez	Investigation of Kiatev cluster
Dr. D. Das	Mr. SubhadipBisal	One Loop calculations in Q.F.T and some applications
Dr. A. Saha	Mr. Debasish Mondal	Band stucture of weyl semi metal nano wire
Dr. A. K. Nayak	Mr. Dipak Maity	Silicon Tracking Detector
Dr. D. Samal	Mr. DigbijayaPalai	Topological spin textures in magnetic heterostructures and interfaces

1.2 DOCTORAL PROGRAM

Presently Institute has fortyeightdoctoral 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. Pronoy Nandi

Advisor: Dr. Dinesh Topwal

Thesis Title: Structural and spectroscopic investigations of organic-inorganic hybrid lead halide perovskites

2. Mahesh Saini

Advisor: Prof. TapobrataSom

Thesis Title: Nanoscale functionalization of ion-beam fabricated self-organized nano structures on silicon surfaces.

3. Partha Paul

Advisor : Dr. Shamik Banerjee

Thesis Title: Some Aspects of Holography and Black Holes.

4. Arpan Das

Advisor: Prof. Pankaj Agrawal

Thesis Title: Manifestation of Entanglement in Quantum Foundation & Quantum Thermodynamics.

5. DebashisSaha

Advisor: Prof. Pankaj Agrawal

Thesis Title: Production of Higgs Boson in Association with another Two Bosons at the Hadron Colliders.

6. 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.

7. Ganesh C. Paul

Advisor: Dr. Arijit Saha

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

8. Mr. Sumit Nandi

Advisor : Prof. Pankaj Agrawal

Thesis Title: Implications of nuclear interaction for nuclear structure and astrophysics within the relativistic mean-field model".

9. Mr. Arpan Das*

Advisor : Prof.Pankaj Agarwal

Thesis Title: Manifestation of Entanglement in Quantum Foundation & Quantum Thermodynamics.

10. Mr. Priyo Shankar Pal*

Advisor: Prof.ArunJayannavar

Thesis Title: Studies on Work Extraction from Small Scale Systems and Fluctuation Theorems.

11. Mr. Ranveer Singh*

Advisor : Prof. T. Som

Thesis Title: Growth and Characterization of CdTe-based Multijunction Hole-blocking Solar Cell.

12. Mr. Mahesh Saini*

Advisor: Prof. T. Som

Thesis Title : Nanoscale Functionalization of Ion-Beam fabricated self-organized Nan ostructures on silicon surfaces.

13. Amina Khatun*

Advisor: Ass. Prof. S.K. Agarwalla

Thesis Title: Constraining New Physics with Atmospheric Neutrinos.

14. ParamitaMaiti*

Advisor : Prof. P.V. Satyam

Thesis Title: Molecular, Beam Epitaxy grown Molybdenum Oxide Nanostructures: Growth, Characterization and Applications.

15. Mr. Pronoy Nandi*

Advisor : Dr. Dinesh Topwal

Thesis Title: Structural and Spectroscopic Investigations of Organic-Inorganic Hybrid Lead Halide Perovskites.

1.4 Summer Students' Visiting Program (SSVP):

The motivation of the SSVP program is to expose young students to frontline research areas, especially in the areas of research work pursuing at the Institute. This year the SSVP was held from 22nd May to 15th July, 2019. Nine students participated in the program. Accommodation in campus was provided to all the visiting students. Under this program, each student worked under the guidance of a faculty member of the Institute. At the end of the program, students presented their work in a seminar on the assigned topics.

Name of the Student	Topic of the Seminar	Advisor
Aparna Rathi	Gas Sensing Properties of Tungsten oxide under different environmental conditions	Prof.T.Som
BhagyarathiSahoo	Characteristics of gas electron multiplier detector	Prof.P.K Sahu
Harsh Raghuwanshi	Ion Implantation in Zinc oxide Thin Films and its electrical Properties	Dr.Satyaprakash Sahoo
KamalakantaJuadi	Characteristics of Proportional counter	Prof. P.K Sahu
Mansi Mandal	Study of optical and electrical properties of Tungsten oxide	Prof.T.Som
Md. Ful Hossain Sk.	Importance of the 1-3 Mixing Angle in three flavor oscillation paradigm	Dr.Sanjib K Agarwalla
Monalisa Sahoo	Proton-Proton collision at LHC	Dr.Arun K Nayak
P. Rakesh Kumar Dora	Basics of Interacting electron system	Dr.Saptarshi Mandal
Sumit Ghosh	Neutrino oscillation in two flavor and three flavor framework	Dr.ManimalaMitra

RESEARCH

2.1. Theoretical High Energy Physics

At IOP, the main areas of high energy physics research are string theory, quantum gravity, black holes, collider and neutrino phenomenology, quark-gluon plasma, astroparticle physics, and cosmology. Individual member's work is in following three categories.

String Theory

String theory — as a broad discipline — has made remarkable progress during last three decades. It has generated ideas that have contributed to several other fields of physics as well as of mathematics. The string theory group has interest in classical and quantum properties of black holes, cosmology, AdS/CFT correspondence, application of gauge-gravity duality to strongly coupled gauge theories, symmetries of string theory, interface of information theory and AdS/CFT etc.

High Energy Physics Phenomenology

The High Energy Physics Phenomenology plays an important role at the energy, intensity, and cosmic frontiers to unravel the deep long-standing mysteries of the Universe. The group research activities have a special emphasis on collider physics, neutrino physics, dark matter, astroparticle physics, and beyond-the-standard-model (BSM) scenarios. Members are exploring the Higgs and top-quark physics, and physics beyond the Standard Model at the ongoing experiments at the LHC, and the proposed experiments at 100 TeV collider, CLIC, ILC, and ep collider LHeC. The work at these colliders involve event-generator based analyses, machine learning, and radiative corrections.

In the neutrino physics, interest is in neutrino oscillation, the detection of the BSM models of neutrino mass generation at ongoing and proposed experiments, and the connection with astroparticle physics. The India-based Neutrino Observatory (INO) is a flagship mega-science project of India to study the fundamental properties of Neutrinos. Members are involved in physics and detector simulation studies related to the Iron Calorimeter detector at INO, and the proposed neutrino experiments named DUNE (in US), and Hyper-Kamiokande (in Japan). The direct and indirect searches of dark matter is also an active field of research these days and the members of the HEP group are quite active in this area of research.

Quark Gluon Plasma, Cosmology and Astroparticle Physics

Quark Gluon Plasma is quite an active field with experiments being carried out at LHC and RHIC. Group members are performing extensive simulations related to quark-hadron phase transitions, and magneto hydrodynamics to understand the flow dynamics. The group members have also been carrying out tabletop liquid crystal experiments which can provide test beds for theories of cosmic defects. They are also spending time to explore the emerging issues in astroparticle physics like dark matter, dark energy, baryogenesis, gravitational waves etc.

(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. "Resistive Magneto hydrodynamics Simulations in relativistic heavy-ion collisions"

We are continuing our work on setting up of a code for resistive magnet hydrodynamics simulations for heavy-ion collisions.

(S.S. Dave, P.S. Saumia and A. M. Srivastava.)

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

We propose a new analogue model of gravity - the evolving quark gluon plasma produced in relativistic heavy ion collisions. A quark gluon plasma is the ``most inviscid" fluid known. Such low viscosity is believed to reflect strongly correlated nature for QGP in these experiments. Hence it may provide a good example of a quantum fluid, naturally suited to studies of acoustic Hawking radiation. Due to rapid longitudinal expansion, presence of a sonic horizon is also naturally present here, though, in general this horizon is not static. Using Ultra relativistic quantum molecular dynamics (UrQMD) simulations, we show that longitudinal velocity of the plasma can become time independent for a short span during the evolution of the system. During this period, 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. We give an estimate of the temperature that she would measure in terms of variables describing the plasma and discuss its observational consequences.

(A. Das, S.S. Dave, O. Ganguly, and A. M. Srivastava.)

3. "Topological defects in QCD matter at high baryon density with centre symmetry Restoration near BEC-BCS boundary of CFL phase"

Lattice calculations by Digal et al. show that centre symmetry is fully restored for SU(3) gauge theory with fundamental Higgs. We apply this to the high baryon density phase of QCD with diquark bound states in 3* representation near BEC-BCS boundary of CFL phase. We are investigating its consequences for topological defects in this regime of QCD and its applications for neutron star physics and for heavy-ion collisions at FAIR and NICA.

(M. Biswal, S. Digal, and Ajit M. Srivastava.)

4. "Calculation of effects of Hawking radiation from acoustic black holes in relativistic heavy-ion collisions on $_{p}T$ distribution of hadrons"

We are calculating the effects of thermal Hawking radiation for the velocity potential field from acoustic black holes in relativistic heavy-ion collisions in terms of a thermal component in the rapidity dependence of the transverse momentum distribution of detected particles.

(S.S. Dave, O. Ganguly, and A. M. Srivastava.)

5. "Initial fluctuations and power spectrum of flow anisotropies in relativistic heavy-ion collisions",

Review article being prepared for European Journal of Physics -Special Topics by Springer. Flow has emerged as a crucial probe for the properties of the thermalized medium produced

in relativistic heavy-ion collisions. The evolution of initial state fluctuations leave imprints on the power spectrum of flow coefficients. Therefore flow coefficients are a crucial probe of initial state fluctuations arising from the parton distributions of the colliding nuclei. This has a very strong correspondence with the physics of power spectrum of cosmic microwave background radiation (CMBR) anisotropies which directly probe initial inflationary fluctuations. Much work has been done to probe these interesting interconnections, in particular, in developing measurements of higher flow coefficients. We review these developments. The effect of initial magnetic field on these features will also be reviewed. All this acquires special importance in view of upcoming electron-ion collider which will directly probe initial parton distribution of the colliding nucleus.

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

Cosmology and astrophysics:

6. "Re-visiting Gravitational wave events via pulsars"

By now many gravitational wave (GW) signals have been detected by LIGO and Virgo, with the waves reaching earth directly from their respective sources. These waves will also travel to different pulsars and will cause (tiny) transient deformations in the pulsar shape. 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 the imprints of past GW events. Some interesting cases are, signal of supernova SN1885 via pulsar B2310+42, should reach earth some time during year 2022 to 2044, and signal of supernova SN1604 via pulsar J1813-1246 during 1971 to 2052. Even the signal of earliest recorded supernova SN185 event may become observable again via pulsars J0900-3144 and pulsar J1858-2216 with perturbed pulsar signal arrival date reaching us during 2016-2049.

(Minati Biswal, Shreyansh S. Dave, and Ajit M. Srivastava.)

7. "Calculation of explicit pulse modification of a pulsar under the influence of external gravitational wave"

For specific gravitational wave (GW) sources, detected by LIGO/Virgo, we are investigating explicit pulse profile modification of a given pulsar under the influence of this GW to predict signal when this pulsar acts as remotely stationed resonant Weber GW detector.

(S.S. Dave, O. Ganguly, and A. M. Srivastava.)

8. "Continuing project: Gravitational wave generation in multi-step electroweak phase transitions"

We study complex patterns of bubble collisions in multi-step first order electroweak phase transitions in extensions of standard model and study its signatures in resulting gravitational waves which can be detected by LISA.

(Peisi Huang and Ajit M. Srivastava.)

9. Shape of the Higgs Potential at Future Colliders.

Although the Higgs boson has been discovered, its self-couplings are poorly constrained. It 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, while it is necessary to use triple-Higgs production at a future 100 TeV proton-proton collider to fully determine the shape of the Higgs potential.

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

10. Di-vector boson production in association with a Higgs boson at hadron Colliders.

We consider the production of a Higgs boson in association with two electroweak vector bosons at hadron colliders. In particular, we examine $\gamma\gamma H$, γZH, ZZH, and W^+W^-H production at the LHC (14 TeV), HE-LHC (27 TeV), and FCC-hh (100 TeV) colliders. Our main focus is to estimate the gluon-gluon fusion contributions to $pp \rightarrow VVH$ ($V=\gamma,Z,W$) and compare them with corresponding contributions arising from the quark-quark channels. Technically, the leading order gluon-gluon fusion contribution to $pp \rightarrow VVH$ cross section is a next-to-next-to-leading order correction in strong coupling parameter, α_s. We find that in the gluon-gluon fusion channel, W^+W^-H has the largest cross section. However, relative contribution of gluon-gluon fusion is more important for the $pp \rightarrow ZZH$ production. At FCC-hh, $gg \rightarrow ZZH$ contribution is comparable with the next-to-leading order QCD correction to $qq \rightarrow ZZH$. Further, we have studied beyond the standard model effects in these processes using the κ-framework parameters κ_t, κ_v, and κ_λ. We find that the gluon-gluon fusion channel processes ZZH and WWH have very mild dependence on κ_λ, but strong dependence on κ_t and κ_v. The quark-quark channel processes mainly depend on κ_v.

(V. Pankaj Agarwal with Debashis Saha and Ambresh Shivaji.)

11. Electroweak corrections to $pp \rightarrow Wbb, Zbb$ at the hadron colliders.

The processes $pp \rightarrow Wbb, Zbb$ are important processes. They are also backgrounds to associated Higgs boson production processes. Electroweak corrections to these processes can be important. There are several hundred one-loop diagrams that contribute to the corrections. These diagrams range from bupple to penta diagrams. There are UV and infrared divergences. UV divergence are being taken care of by the renormalization procedure. The infrared divergences are being removed by dipole-subtraction procedure. After these procedures we get a finite result. Along the way there are many technical complications that are being taken care.

(Pankaj Agarwal with Biswajit Das.)

12. AdS/CFT correspondence.

Computation of higher point correlators of operators with high scaling dimensions of certain strongly coupled field theories on cosmological

backgrounds. We have been able to compute two point correlators earlier on Kasner class of geometries. Now we are trying to compute three point correlators. AdS/CFT techniques are used for the computations

(S. Mukherji)

13. An observer accelerating uniformly in flat Minkowski space experiences a heat bath having a temperature proportional to the magnitude of the acceleration. There are various ways to understand this. One way is to use the instanton techniques. We are exploring a similar approach on AdS, where the boundary is a Minkowski space on which an accelerating observer experiences a heat bath.

(S. Mishra, S. Mukherji and Y. Srivastava.)

13. Constraints on Flavor-Diagonal Non-Standard Neutrino Interactions from Borexino Phase-II.

The Borexino detector measures solar neutrino fluxes via neutrino-electron elastic scattering. Observed spectra are determined by the solar- e survival probability Pee(E), and the chiral couplings of the neutrino and electron. Some theories of physics beyond the Standard Model postulate the existence of Non-Standard Interactions (NSI's) which modify the chiral couplings and Pee(E). In this paper, we search for such NSI's, in particular, flavor-diagonal neutral current interactions that modify the ee and ν_τe couplings using Borexino Phase II data. Standard Solar Model predictions of the solar neutrino fluxes for both high- and low-metallicity assumptions are considered. No indication of new physics is found at the level of sensitivity of the detector and constraints on the parameters of the NSI's are placed. In addition, with the same dataset the value of $\sin^2\theta_w$ is obtained with a precision comparable to that achieved in reactor antineutrino experiments. This paper got published in JHEP 2002 (2020) 038.

(S.K.Agarwala.)

14. Physics Potential of ESS SB in the presence of a Light Sterile Neutrino.

ESSνSB is a proposed neutrino super-beam project at the ESS facility. We study the performance of this setup in the presence of a light eV-scale sterile neutrino, considering 540 km baseline with 2 years (8 years) of neutrino (antineutrino) run-plan. This baseline offers the possibility to work around the second oscillation maximum, providing high sensitivity towards CP-violation (CPV). We explore in detail its capability in resolving CPV generated by the standard CP phase δ_{13}, the new CP phase δ_{14}, and the octant of θ_{23}. We find that the sensitivity to CPV induced by δ_{13} deteriorates noticeably while going from 3ν to 4ν case. The two phases δ_{13} and δ_{14} can be reconstructed with a 1σ uncertainty of ~15^0 and ~35^0 , respectively. Concerning the octant of θ_{23}, we find poor sensitivity in both 3ν and 4ν schemes. Our results show that a setup like ESS SB working around the second oscillation maximum with a baseline of 540 km, performs quite well to explore CPV in 3ν scheme, but it is not optimal for studying CP properties in 3+1 scheme. This paper got published in JHEP 1912 (2019) 174.

(S.K.Agarwala)

15. Flat Space Holography

My current research is focussed on flat space holography which is an equivalence between

quantum theory of gravity in flat space-time and a quantum field theory without dynamical gravity. I study various properties of this (dual) quantum field theory using the connection between soft and collinear factorisation of S-matrix elements of gluons and gravitons and asymptotic symmetries in flat space-time. The primary aim of this research, from quantum gravity or string theory point of view, is to understand better the intriguing properties of classical and quantum black holes in our universe.

(S.Banerjee)

16. Probing Doubly and Singly Charged Higgs at HE-LHC.

In this work, we analyse the signal sensitivity of multi-lepton final states at collider that can arise from doubly and singly charged Higgs decay in a type-II seesaw framework. We assume triplet vev to be very small and degenerate masses for both the charged Higgs states. The leptonic branching ratio of doubly and singly charged Higgs states have a large dependency on the neutrino oscillation parameters, lightest neutrino mass scale, as well as neutrino mass hierarchy. We explore this as well as the relation between the leptonic branching ratios of the singly and doubly charged Higgs states in detail. We evaluate the effect of these uncertainties on the production cross-section. Finally, we present a detailed analysis of multi-lepton final states for a future hadron collider HE-LHC, that can operate with 27 TeV center of mass energy

(Rojalin Padhan, Debottam Das, Manimala Mitra, Aruna Kumar Nayak.)

17. Probing Lepton Flavor Violating decays in MSSM with Non-Holomorphic Soft Terms.

It is known that the Minimal Super-symmetric Standard Model (MSSM) can be extended to include non-holomorphic trilinear soft SUSY breaking interactions that may have distinct signatures. We consider non-vanishing off-diagonal entries of the coupling matrices associated with holomorphic (of MSSM) and non-holomorphic trilinear terms associated with sleptons We first improve the MSSM charge breaking minima condition of the vacuum to include the off-diagonal entries in the holomorphic and non-holomorphic trilinear couplings. We further extend this analysis for non-holomorphic trilinear interactions. No other sources of lepton flavor violation like that from charged slepton matrices are considered. We constrain the interaction terms via the experimental limits of processes like charged leptons decaying with lepton flavor violation (LFV) and Higgs boson decaying to charged leptons with LFV. Apart from the leptonic decays we compute all the three neutral LFV Higgs boson decays of MSSM. Considering the charge breaking constraint, flavor observables, apart from the Higgs mass data, we analyze the above processes with non-holomorphic interactions and compare the results with that of MSSM. Ref:e-Print:1911.05543 [hep-ph]

(Utpal Chattopadhyay, Debottam Das, Samadrita Mukherjee.)

18. Minimal model of torsion mediated dark matter.

We present a minimal model of fermionic dark matter (DM), where a singlet Dirac fermion

can interact with the Standard Model (SM) particles through the torsion field of gravitational origin. In general, torsion can be realized as an antisymmetric part of the affine connection associated with the spacetime diffeomorphism symmetry, thus can be thought of as a massive axial vector field. Because of its gravitational nature, torsion couples to all the fermion fields including the DM with equal strength, which makes the model quite predictive. The DM is naturally stable without any imposition of ad-hoc symmetry. Apart from producing the correct thermal abundance, singlet fermion can easily evade the stringent bounds on the spin-independent DM-nucleon direct detection cross-section due to its axial nature. However, in the allowed parameter space, strong bounds can be placed on the torsion mass and its couplings to fermions from the recent LHC searches. Assuming a non-universal torsion-DM and torsion-SM couplings, smaller values of torsion masses may become allowed. In both cases, we further study the reach of the spin-dependent direct detection searches of the DM.

Ref:e-Print: 1912.09249 [hep-ph] (Phys.Rev.D 101 (2020) 7, 075017)

(Basabendu Barman, Tapobroto Bhanja, Debottam Das, Debaprasad Maity.)

19. Enhancement of Higgs Production through Leptoquarks at the LHC.

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 singlet scalar and the LQ is allowed. Here, the quark fusion process can have significant cross section, specially for a light singlet scalar. 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.

Ref: e-Print: 2002.12571 [hep-ph]

(Arvind Bhaskar, Debottam Das, Bibhabasu De, Subhadip Mitra.)

20. The research work of Dr. Mitra explores the phenomenological aspects of beyond standard model of neutrino mass generation. Five publications including preprints have been made during 01.04.2019-31.03.2020. Among these publications, in Phys. Rev. D 101, 075050, Phys.Rev. D99 (2019) no.11, 115015, we looked into doubly charged Higgs production and its signature at various colliders. Additionally, in Phys.Rev. D100 (2019) no.9, 095022, we explored lepton number violating rare meson decays. Finally, in Phys.Rev. D101 (2020) 075037, we

explored the prospect of discovery of a R2-tilde leptoquark model at the future ep collider.

(M.Mitra)

21. Multi-charged scalars and fermions in the framework of a radiative seesaw model @LHC.

Collider signature of a model for radiatively (1-loop) generated neutrino masses have been studied. The model includes new scalar and fermion doublets/singlets in the framework of the SM gauge symmetry. The hypercharges of these new scalars/fermions are assigned in such a way that no additional Z2 symmetry is required to forbid the couplings which lead to the generation of neutrino masses at tree level. As a result, the particle spectrum of this scenario includes singly, doubly and triply charged scalars which gives rise to interesting multi-lepton signatures at the Large Hadron Collider (LHC). We studied the LHC phenomenology of these multi charged scalars and obtain bounds (on the masses) from existing LHC searches. We have also proposed new search strategies for future LHC runs. Final results are presented in Fig. 1.

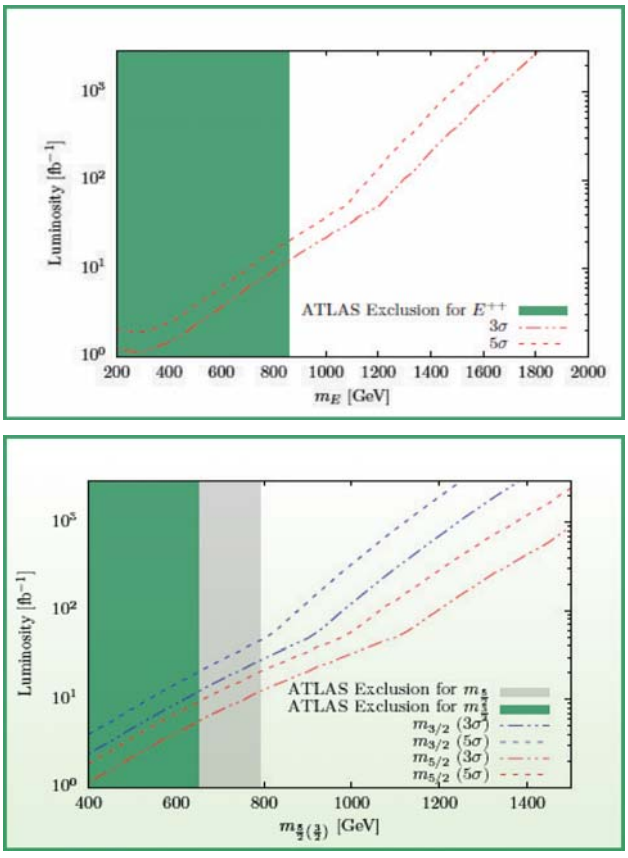


Fig.-1 : With our proposed event selection criteria, required luminosities for 3**σ** (5**σ**) discovery of the doubly-charged fermion (left panel) and singly- as well as triply-charged scalars are plotted as a function of the respective particle mass. The shaded regions correspond to the parts of parameter space which are already excluded by the LHC searches.

(Avnish, Kirtiman Ghosh.)

22. Phenomenology of universal extra-dimensional scenarios

The minimal version of UED (mUED) is characterized by a single flat extra dimension (y), compactified on an S_1/Z_2 orbifold with radius R, which is accessed by all the SM particles. The key feature of the UED Lagrangian is the conservation of the momentum along fifth direction which ensures the stability of the lightest level-1 KK particle (candidate for DM). mUED is nonrenormalizable and should be treated as an effective theory valid upto a cutoff scale Λ. The phenomenology of mUED is determined by R and Λ. The pair production of level-1 KK particles gives rise to interesting multi-jets plus missing energy signatures (SUSY like) at the colliders. We have studied ATLAS results (ATLAS-CONF-2019-040) for multi-jets plus missing energy channels with 139 fb^{-1} integrated luminosity and obtain bounds on R^{-1}-ΛR plane. The results are presented in Fig. 2. We conclude that DM relic density allowed part of mUED parameter space is ruled out from LHC searches. Presently, we are developing the tools for the phenomenology of non-minimal UED scenarios.

(Avnish, Kirtiman Ghosh)

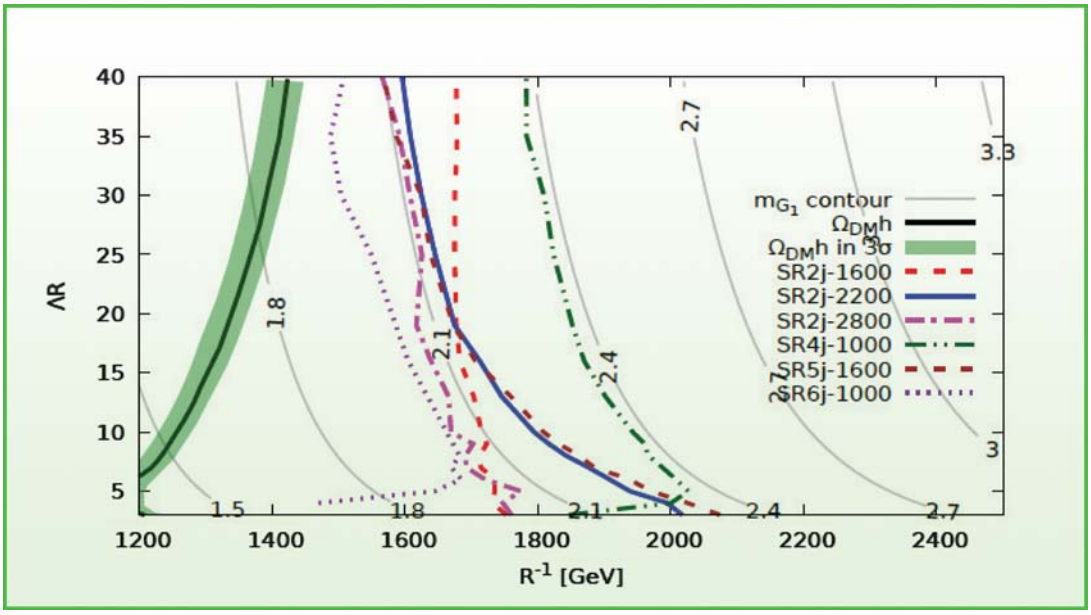
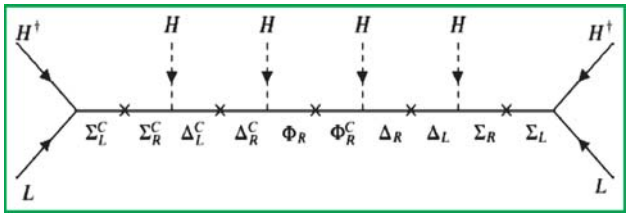


Fig.-2 : Different constraints on the parameter-space of mUED secnario.

23. Model for generating neutrino masses@ tree-level via dim-9 operator.

While keeping the symmetry of the SM gauge group $SU(3)_C \times SU(2)_L \times U(1)_Y$ unaltered, we extend the fermionic sector of the SM by vector-like $SU(2)_L$ triplets (ΔL,R), vector-like $SU(2)_L$ quadruplets (ΔL,R) and chiral $SU(2)_L$ quintuplets (Φ_R). The tree level diagram generating neutrino masses is presented in the Fig. 3. We have shown that the observed neutrino masses and mixings can effortlessly be accommodated in this model. We studied the phenomenology of this model in the context of LFV and collider experiments.

(Ashanujjaman, Kirtiman Ghosh.)



24. The SM with new generations of Z_2-odd vector like leptons and quarks.

We introduce new generations (two) of vector like leptons and quarks in the framework of the SM gauge symmetry. This scenario could lead to tiny neutrino masses at 1-loop level, explain muon g-2 anomaly, provide a cosmologically viable candidate for dark matter and give rise to interesting signatures at collider experiments. We have already studied neutrino mass, muon g-2 and dark matter relic density in the context this model. Presently, we are working on the collider phenomenology of this scenario.

(Vandana Sahdev and Prof. Debajyoti Choudhury, Kirtiman Ghosh.)

25. Study of the analyticity properties of scattering amplitude in higher dimensional field theories.

I have been persuing rigorous study of the analyticity properties of scattering amplitude in

higher dimensional field theories. PoS ICHEP2018 (2019) 266 is a summary of my works over two years which was presented in ICHEP. I start from LSZ axioms for theories in D > 4. First the amplitude is computed using reduction technique. Then the analog of Jost-Lehmann-Dyson theorem was proved for a theory in D > 4. The amplitude is expanded on a basis which is Gegenbauer polynomial (for D = 4, it is Legendre polynomial). The existence of small Lehmann ellipse and large Lehmann ellipse was proved. A theorem to show enlarged domain of analyticity was proved in sequel. Finally, the generalized Froissart-Martin theorem was proved for the total cross section in D-dimensions:

$$\sigma_t(s) \leq C \log^2(s/s_0)$$

s is squared of c.m. energy. The prefactor, C, was determined from first principles. s_0 cannot be determined ab initio. ?

(Prof. J. Maharana (INSA Senior Scientist)

26. Forward dispersion relations for a theory with a compact spatial dimension.

The second problem was to prove forward dispersion relations for a theory with a compact spatial dimension. Khuri studied this problem in nonrelativistic potential scattering. He concluded that, in potential scattering, the forward scattering amplitude does not satisfy analyticity properties in certain cases. If it would so in a relativistic field theory with a compact dimension there will be very serious concern. Analyticity and causality are very intimately related in relativistic QFT.

I started from a D = 5 massive field theory in Minkowski space and compactified one spatial coordinate on S^1. I start with LSZ formulation in D = 5 and examine the consequences with S^1 compactification. The geometry is $R.^{3,1} \otimes S^1$. Thus reduced theory has K K towers and all these states have to be retained. I set up the reduction formalism. Next the spectral representation for absorptive parts were derived. The third step was to obtain generalized unitarity condition for S-matrix from LSZ. I argued, following Symanzik, for my case that the forward amplitude is polynominally bounded in s. Finally, the crossing was proved by an indirect method. Finally, the dispersion relations were proved for forward amplitude in a field theory defined on $R^{3,1} \otimes S^1$ which is obtained from compactification of a D = 5 scalar field theory in flat space.

Remarks: Causality is a fundamental axiom of axiomatic field theory. Two local operators commute if they are separated by spacelike distance. In usual field theory, dispersion relations are proved from causality in the linear programme i.e. unitarity is not invoked. In nonrelativistic quantum mechanics, there is no concept of microcausality since there is no limiting velocity. Thus violation of analyticity does not lead to any serious issue. In Relativistic QFT if analyticity is violated then axioms of QFT will be questioned. Ref: Nucl.Phys. B (2019) 114619.

Prof. J. Maharana (INSA Senior Scientist)

2.2. Theoretical Nuclear Physics

From the inception of Institute of Physics, Bhubaneswar, Theoretical Nuclear Physics is one of the major subjects of research in the institute. The group has a major contribution to the International Nuclear Physics Community on Theoretical Nuclear Structure Physics. The knowledge on Nuclear Structure is essential to understand various nuclear phenomena. The activities on Nuclear Structure had been started from the early days since 1975. It is major area of research in Nuclear Physics today at Institute of Physics, Bhubaneswar.

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

1. Summary of work in Nuclear Physics Theory and Nuclear Astrophysics

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

(S. K. Patra)

2. Application of Nilsson model for deformed nucleus in relativistic heavy ion collisions

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. Incorporating shape modification in WS, earlier attempts were made to explain observables in deformed nucleus such as Uranium (U). Although the shape of distribution remains consistent, the Modified Wood Saxon (MWS) overestimates the particle multiplicities. In this work, 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

(S. K. Tripathy, M. Younus and P. K. Sahu)

3. Comparison of theoretical directed and elliptic flow of protons in Au+Au reactions at 1.23 A GeV with the recent HADES data at GSI.

Using theoretical dynamical simulation relativistic model, we discuss, the flow harmonics along with the HADES experiment at GSI, which has provided preliminary data on the directed flow, elliptic flow, and triangular flow of protons in Au+Au reactions at a beam energy of 1.23 A GeV, recently. We discuss the softness and momentum dependent interaction in our simulation model and compare with the data.

(P. K. Sahu and S. Sahoo.)

4. Relativistic interacting Hadron-Resonance Gas model.

The Hadron Resonance Gas (HRG) model is used for small baryon chemical potential and finite temperature to model hadronic matter. Here we extend this model for finite and large chemical potentials, that is for high baryon density by introducing the interaction between the baryons only based on the relativistic mean field theory. Using the lattice data at small chemical potential and the nature of equation of state (attractive and repulsive), we constraint the interacting HRG model. We then calculate the effect of experimental acceptance on the ratios of the mixed susceptibilities using this model.

(P. K. Sahu and D. Mishra)

2.3. Experimental High Energy Physics

The goal of High Energy Physics is to understand the basic constituents of matter and their interactions. The theoretical framework developed by Glashow, Salam, and Weinberg to describe the interactions between the known elementary particles is known as the Standard Model (SM) of particle physics. The cornerstone of the Standard Model is the Higgs mechanism, which is believed to give mass to all elementary particles. A Higgs boson, a particle corresponding to the Higgs field, was recently discovered at the Large Hadron Collider (LHC) at CERN, Geneva, Switzerland. A collider is a particle accelerator that accelerates two beams of particles in opposite directions to a very high energy and collides them against each other at designated interaction points where sophisticated particle detectors are placed to detect new particles produced in the collisions.

Also the goal of the High Energy heavy-ion research program is to explore the QCD phase diagram in the region of high baryon densities using high energy nucleus-nucleus collisions (RHIC(STAR), LHC(ALICE), FAIR(CBM)). This includes the study of the equation-of-state of nuclear matter at neutron star core densities and the search for phase transitions and exotic forms of QCD matter.

At IOP, there are two experimental high energy physics groups participating in the collider-based experiments at various international laboratories. One group participates in the Compact Muon Solenoid (CMS) experiment at LHC, CERN. It is involved in the studies of SM particles and searches for beyond the SM particles in proton-proton collision events collected by the CMS detector. The other group is involved in the studies of Quark-Gluon plasma, production of new particles and a state of matter in the early universe, which are recreated in heavy ion collisions. It participates in the STAR experiment at RHIC, BNL, USA, ALICE experiment at LHC, CERN, and the proposed CBM experiment at FAIR, GSI, Germany. Apart from the physics studies the groups also contribute to the R&D of the state-of-the-art detectors for the present and future experiments.

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

1. Data Analysis in Heavy-ion collisions:

Proton-nucleus collisions are important in addressing cold nuclear matter, initial conditions, energy loss and parton multiple scattering. Parton distributions are affected by various phenomena like nucleon overlap in nucleus, or EMC effect and leading to depletion of partons at high x. Parton rearrangement for the same reason give rise to shadowing (depletion at x<.04) and anti-shadowing (enhancement x~0.1). It is inevitable to understand the effects to get a clear knowledge on hot de-confined state of hadronic matter (QGP) formed in relativistic heavy ion collisions.

1.1 Study of Λ(1520) resonance at ALICE Energies:

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. In particular, the Λ(1520) (commonly known as Λ* baryonic resonance) is important because its lifetime (~12.6 fm/c) is comparable to the time scale of the hot and dense matter produced in heavy-ion collisions.

The characteristic properties such as mass, width, yield and transverse momentum spectra of Λ* may be very sensitive to the dynamics and in-medium effects. Basically the decay products of Λ* the protons and kaons, may undergo in-medium effects such as re-scattering. The re-generation process (pseudo-elastic interactions; p+K → Λ* → p+K) may compensate for the Λ* yield, lost in re-scattering, if the system formed has a long expansion time.

We have studied production of Λ in p-p and p-Pb collisions at 7 TeV and 5.02 TeV, respectively. We have the following findings from this study. Λ* follows mass ordering in $\langle p_T \rangle$ for both p-p and p-Pb collisions. Λ* Strangeness content can be a key factor of yield enhancement in higher multiplicity bins. This enhancement is independent of mass of a particle. Hadronic scattering medium has negligible effect on its yield over charge particle multiplicity. This measurement may help models to have a upper bound of the hadronic scattering medium in p-Pb collisions at 5.02 TeV.

For ALICE Collaboration: S. Sahoo, R. C. Baral and P. K. Sahu

1.2 Ks/Lambda/Anti-Lambda/Xi/Anti-xi in U+U 193 GeV at STAR:

We investigate strangeness production in STAR experiment at RHIC in U+U 193 GeV collisions. Weak decay particles like Ks/ Lambda/Xi have been reconstructed from their hadronic decay channels. Reconstructed masses are in consistent with PDG values. These particles transverse momentum spectra have been corrected with detector acceptance, efficiency and branching ratio. Omega reconstruction is under process. We are also comparing these results with Au+Au 200 GeV results.

(For STAR collaboration: S. Tripathy and P. K. Sahu.)

2. High Energy Experimental Laboratory for ALICE and CBM

2.1. Characterizations of GEM detector prototype

Gas Electron Multipliers (GEM) detector possess high rate capability and high resolution as compared to the detector based on the wire chamber or tracking drift chamber principle. This is because, the GEM has been used in high-energy experiments such as COMPASS, TOTEM, CMS and ALICE experiment at CERN and PHENIX experiment at BNL.

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

(P. K. Sahu, A. Tripathy, S. Swain, S. K. Sahu and B. Mallick).

2.2. Ion Backflow fraction of quadruple GEM detector

A systematic investigation is done for the study of ion backflow fraction with GEM based detectors. The ion current along with detector gain is carefully measured in various voltage configurations and with different gas proportions. The observed ion backflow fraction seems to be very sensitive towards drift field and effective gain of the detector. Further with decrease in quencher component of the gas mixture gain changes, consequence a change of ion fraction going towards drift volume. The main idea is to optimize the detector for the lowest ion backflow current. For that a detailed scan over drift and induction field is done with varying gas ratio. A minimum ion backflow fraction of 3.5%, 3.0%, 3.8% is obtained with drift field 0.1kV in Ar:CO_2 gas in 70:30, 80:20 and 90:10, ratios respectively.

(A.Tripathy, P. K. Sahu, S. Swain and S. K. Sahu.)

2.3. Simulation:

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

(S. Swain and P. K. Sahu.)

2.4. HV Control system for MUCH detector for CBM:

The Basic motivation of this HV control system is to isolate the high current drawing sections of the GEM detector from the remote location. It is planned to back up the power of the latch using SUPER capacitor. The control communication is designed using UDP protocol. The system is hosted as web server in the LAN. 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.

(S. Sahu, P. K. Sahu and B. Mallick)

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

The CMS group at IOP is involved in the searches for ttH production in final states with

tau leptons in pp collision data recorded by the CMS experiment at a centre-of-mass energy of 13 TeV. The Higgs boson coupling to fermions in Standatd Model (SM) is proportional to the fermion mass. Therefore, the measurement of the Yukawa coupling of the Higgs boson to top quark, y_t, is of high phenomenological interest due to extraordinary large values of the top quark mass compared to all other known fermions. The top quark Yukawa coupling is measured indirectly from the Higgs boson production in gluon fusion process, and agrees well with the SM expectation. However, the measurement can be affected by the contribution of beyond SM (BSM) particles to the loop diagram. Hence, the measurement of the production rate of Higgs boson in association with top quark pairs (ttH) provides the most precise model independent measurement of y_t.

Our analysis focuses on the final states where the Higgs boson decays to a pair of tau leptons. The sensitivity of the analysis is enhanced by means of two different multivariate analysis techniques. Our group played a leading role in developing the multivariate discriminant based on boosted decision tree (BDT) for this analysis carried out using 2016 and 2017 data. The analysis with 2016 data, in combination with all possible ttH search channels had resulted in an observation of ttH process at CMS with 5.2σ significance, and was publised in PRL. Furthermore, we added a new final state with two hadronic tau leptons and no additional light leptons for analysis with full 13 TeV data collected during LHC run-2. We performed full analysis in this final state including that of background estimation using data-driven techniques. We also performed studies on the normalization of Z to tautau backgrounds from data using the events with Z boson decaying to a pair of muons. The analysis with full run-2 data is going through CMS internal physics approval process.

We are making significant contributions to the measurement of Higgs boson CP properties in its decay to a pair of tau leptons. The Higgs boson in the SM is expected to have a CP quantum number of +1 (CP even state). However, various BSM models predict additional Higgs bosons, including the ones that can be CP odd (CP=-1) or a mixture of the two (not a CP eigen state). The decay of the Higgs boson to a pair of tau leptons provide a model independent method to probe the CP properties of the Higgs boson. The angle between the decay planes of the two tau leptons is not only able to discriminate between the CP odd and CP even states but also between CP eigen and CP mixture states. However, at LHC, the reconstruction of the decay plane of the tau lepton is not always possible due to missing neutrinos. Therefore, an alternative method, using the impact parameters of the charged pions originating from tau lepton decays, are being utilied to reconstruct the decay plane. The method retains significant amount of the discriminating power, however, it is significantly affected by the detector resolution. We made several studies to understand the impact of various detector resolutions on the CP discriminating observable and possible mitigation methods. Furthermore, we developed full analysis strategy, including machine learning methods for signal-background separation and estimation of backgrounds from data. We are working towards a publication with full 13 TeV data recorded by CMS.

We are also 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. The analysis involves kinematic fitting to fully reconstruct the top quark pair from their decay products. The result of the analysis with 13 TeV pp collision data recorded during 2016 has been published as a CMS-PAS, and is being going through CMS internal approval process for a journal publication. The result provides stringent exclusion limit to date for this channel.

We are partially involved in the analysis for a search for top s-quark pair production in a final state with two tau leptons in proton-proton collisions at sqrt(s) = 13 TeV. The results has been already published in JHEP.

(A Nayak, Vinaya Krishna Nair, Diwakar and Collaborators.)

4. Contributions to the development of object identification and high-level trigger in the CMS experiment.

The CMS group at IOP contributes significantly to the development of reconstruction and identification algorithms of the hadronic decays of tau leptons. In particular, we played leading role in development of multivariate (MVA) isolation for Run-2 of LHC using boosted decision trees (BDT). Furthermore, we worked on re-optimizing the isolation sum discriminants for the data recorded during 2017, and provided two more high efficiency-working points that may be helpful to analyses, such as high p_T SUSY searches, requiring higher signal efficiency. We have been taking responsibility for the validation and performance measurements of the tau lepton triggers during 2018 data taking and thereafter till date.

We were involved in the coordination of activities related to the development of jets and missing transverse energy trigger in the High Level Trigger (HLT) of the CMS experiment from September 2016 to August 2019. The reconstruction of jets and missing tranverse energy at the HLT is crucial for the design of many trigger paths that are used to record data for Higgs, SUSY, and many other new physics searches. In addition to the coordination task the group contributed to the measurement of the trigger performance in data. We measured efficiency for jet and missing transverse energy triggers with respect to that 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.

(A Nayak, Vinaya Krishna Nair, Diwakar and Collaborators.)

5. R&D for buliding functional test setups to test the silicon-strip tracker detector modules.

India-CMS collaboration plans to contribute significantly to the phase-II upgrade of the CMS detector for HL-LHC. Towards this effort, we are trying to develop a silicon-strip tracker detector module functional test set up, which will be used to test the modules during their assembly. For this purpose we have procured necessary equipment such as power supplies, custom made readout cards, oscilloscope, etc. A few small components are also being fabricated in the institute workshop. In addition, we have been preparing the laboratory space along with necessary infrastructure to carry out these measurements.

(A Nayak, Ramarani Dash.)

2.4 Quantum Information

Quantum information science is one of the frontier areas of science and technology. It is also an interdisciplinary area of research where scientists from physics, mathematics, and computer science can contribute alike. Three major areas of interest are quantum correlations, quantum nonlocality, and quantum communication protocols. In the area of quantum correlations, the goal has been better understanding the correlations in bipartite mixed states and multipartite states. Issue has also been if there are quantum correlations beyond entanglement. Characterization, quantification, and manipulation of correlations in a quantum system can have far-reaching technological ramifications. Quantum nonlocality leads to enduring mysteries of quantum mechanical formalism. There are also systems like Popescu-Rohrlich box, which display more nonlocality than a quantum system. The group is working on better understanding of this phenomenon beyond bipartite pure states, i.e. mixed states and pure multipartite states. One of the triumphs of this field has been introduction of new means of communications using entanglement as a resource. The group has been exploring many such protocols, such as secret sharing, in multipartite settings.

(P. Agrawal)

1. Resource state structure for cooperative quantum key distribution.

Quantum entanglement plays an important role in many communication protocols, like teleportation, superdense coding, secret sharing and quantum cryptography. We work in a scenario where more than two parties are involved in a protocol and share a multipartite entangled state. In particular, we introduce a protocol of Cooperative Quantum Key Distribution (CoQKD), where, two parties, Alice and Bob establish a key with the cooperation of other parties. Other parties control whether Alice and Bob can establish the key, its security and key rate. We find suitable resource states for maximal CoQKD in the case of three and four parties. In the three-qubit scenario, We discuss the controlling power of the third party, Charlie. The new resource states are also suitable for generating conference key where a key is shared by all parties. We find that recently introduced Bell inequalities can help to establish the security of the conference key.

We also discuss cooperative teleportation using the new states.

(Pankaj Agarwal with Arpan Das, Sumit Nandi, Sk Sazim)

2. Entanglement dependent bounds on conditional-variance uncertainty relations.

We formulate the conditional-variance uncertainty relations for general qubit systems and arbitrary observables via the inferred uncertainty relations. We find that the lower bounds of these conditional-variance uncertainty relations can be written in terms of entanglement measures including concurrence, G function, quantum discord quantified via local quantum uncertainty in different scenarios. We show that the entanglement measures reduce these bounds, except quantum discord which increases them. Our analysis shows that these correlations of quantumness measures play different roles in determining the lower bounds for the sum and product conditional variance uncertainty relations. We also explore the violation of local uncertainty relations in this context and in an interference experiment.

(Pankaj Agarwal with Shrobona Bagchi and Chandan Datta)

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. One of our main goals 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, B. R. Sekhar, P. V. Satyam, T. Som, D. Topwal, S. Sahoo, D. Samal)

1. A. Phase transition and enhanced photo-absorption properties in Ion irradiated TiO_2 films

Ion implantation of TiO_2 thin films was carried out at IUAC, New Delhi. These films show creation of nanostructures and anatase-rutile phase transition. Presence of oxygen vacancies become crucial for this transition. The irradiated films exhibit bipolar resistive switching (RS) behavior and unusual photoabsorption properties.

(S. Varma)

B. ZnO sensor with metal conjugation for non-enzymatic Amperometric Glucose sensing measurements.

We have electrochemically grown sensors for developing Amperometric Glucose sensor. For this, electro chemical deposition of ZnO with small concentrations of metal was carried out in the growth cell in absence of Enzymes. Glucose sensing is calibrated by CV technique and time dependent measurements.

(S. Varma)

C. Scaling studies of Dynamic Evolution of surfaces fabricated by ion irradiation on thin TiO_2 films

Ion implantation experiments were carried out at IUAC, Delhi. Ion implantation of TiO_2 thin films produces nano-patterning on the surfaces. The nanopatterned thin films have been investigated by Scanning Probe Microscopy (SPM) and Angle Resolved X-ray Photoelectron Spectroscopy (ARXPS). The results indicate presence of oxygen vacancies on the surface. The Scaling properties show that the diffusion on the surface is crucial for the evolving dynamics. The growth and roughness exponents have also been studied.

(S. Varma)

D. Adsorption properties of DNA on Nano-patterned oxide Surfaces.

Oxides surfaces show many biocompatible properties. SiOx and TiO_2 Surfaces were nanopatterned with ion beams to produce efficient surfaces for DNA conjugation. These surfaces were interacted with circular plasmid DNA. Combined AFM, XPS, UPS studies display that the electronic structure modifications promote many interesting adsorption properties.

(S. Varma)

E. Utilizing Organic Molecules to detect and arrest Toxic Arsenic contamination in Water

Thin films of organic molecules are being utilized for detecting and arresting Arsenic pollution in Water. We are utilizing the Raman, FTIR and UV-Vis studies to understand the mechanism of conjugation. DFT studies are also being used.

(S. Varma)

F. Studies of Solar Cell related applications using Metal doped Sulphide nanoparticles

Metal doped nanoparticles of many Sulphide compounds are being studied using techniques like XPS, UPS, FTIR etc. These materials show many interesting

photoabsorption properties. XPS, UPS and UV-Vis measurements have been performed for understanding the reasons for intense work-function changes.

(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. Lots of research work is also being devoted to explore the technologically important properties of these materials, especially in the area of spintronics and quantum computing. 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 (Ef) electronic structure can also lead to other distinct systems, like Weyl semimetals, topological crystalline insulators, topological Dirac semimetals etc. The SSs in TIs are characterized by the time reversal invariant Z2. TI systems fall into the category of strong or weak according to the 0 value 1 and 0 respectively. 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.

Earlier, we have undertaken some detailed studies of the band structure of various TIs using ARPES as well as theoretical DFT methods, focused mainly on tuning the Dirac nodes and understanding the dynamics of the fermions. Now, we have performed ARPES studies on compositions of BiSe, $Bi_{2-x}Cu_xSe$, $Bi_{1-x}Sb_xSe$ and Weyl semimetals 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_{4I4}, 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

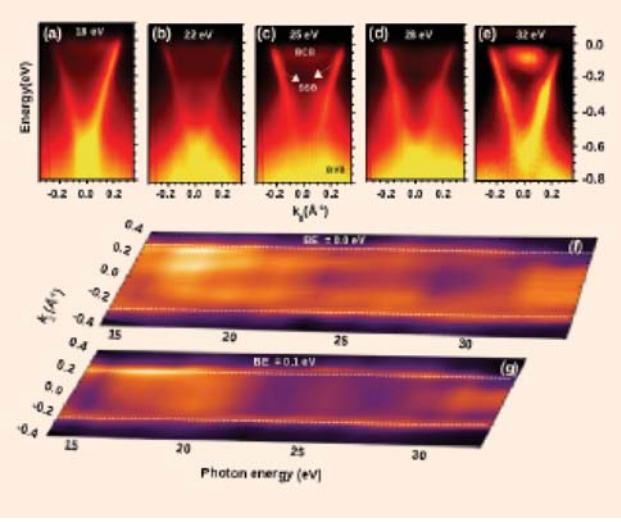


Fig.-1: ARPES images of BiSe taken by using photon energies (p-polarization) 18eV (a), 22eV (b), 25eV (c), 28eV (d) and 32eV (e). Sample alignment was close to the Gamma-M direction. (f) and (g) CEC of BiSe constructed from the MDCs at BE = 0.0 and 0.1eV respectively obtained from the ARPES images of photon energies (p-polarization) 14eV to 34eV.

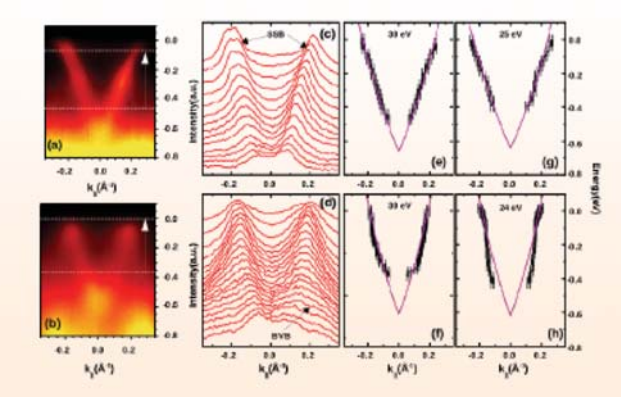


Fig.-2: (a) and (b) ARPES images of the Gamma-M oriented sample of BiSe and Bi0:92Sb0:08Se respectively measured at an excitation energy of 30eV (p-polarization). (c) and (d) MDC extracted from the ARPES images (a) and (b) respectively.

surface of BiTe using ARPES measurements. These materials show significant 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. A major part of the research work was on the growth, characterization and application of 2Dlayered nanostructures, in particular MoO_x nanostructures. Extensive works were carried out growing β-MoO_3 and meta-stable α-MoO_3 nanostructures on various substrates andvarious conditions. The growth has been carried out by various thin film growth methods, such as, physical vapor deposition in high vacuum, molecular beam epitaxy (MBE) technique under ultra-high vacuum (UHV) conditions, Chemical Vapor deposition methods with varying parameters, such as, substrates, substrate temperature, film thickness, etc. and their applications. We have used MoO_3 for many purposes. NALCO Project: Nano Alumina powder film as anti-reflection coating film and reinforcementof Aluminum with nano-alumina powder.Under this project, we have succeeded in enhancing the efficiency by depositing nano alumina coatings.

(P. V. Satyam)

4. A. Ion-beam induced nanoscale patterning of semiconductors and their functionalization

i. Self-organized pattern formation

This project focuses on the fabrication of self-organized patterned semiconductor substrates

using low-to-medium energy (0.5-60 keV). Interestingly, keV Au ions yields nanowire-like patterned Ge substrates with extreme regularity (laterally spanned up to tens of μm). On the other hand, at low ion energies, ripples are formed on Si surface which undergoes a transition to facets under a stipulated 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 sputtering. Presently, we are working on patterning III-V semiconductors.

(Prof. T. Som)

B. Functionalization of nanopatterned semiconductor surfaces

i. Tailoring anisotropic optical properties of gold nanoparticle-decorated nanoscale Si ripples

In this work, we have studied plasmonic anisotropy and surface-enhanced Raman scattering-based molecular detection efficacy of oblique angle grown self-organized gold nanoparticles (Au-NPs) on ultralow energy ion-beam fabricated nanoscale rippled-Si (R-Si) substrates. To study the effect on plasmonic field coupling, the shape of Au-NPs is tuned from elongated to spherical ones by varying the growth angle of Au-NPs, leading to a change in the inter-particle gap. Following this, post-growth annealing of Au-NP arrays is carried out to change the shape and size of Au-NPs via Ostwald ripening process. Enormous near-field enhancement between Au-NPs leads to surface-enhanced Raman scattering (SERS)-based detection of an ultralow concentration of crystal violet dye. Simulation reveals that hotspot formation takes place between Au-NPs due to lesser inter-particle gaps along the Au-NP arrays compared to the ones between two adjacent arrays. The improved SERS-based detection efficacy of complex molecules is attributed to their enhanced Raman scattering cross-section in the vicinity of these hotspots.

(Prof. T. Som)

ii. Cold cathode electron emission with ultralow turn-on field from gold nanoparticle-decorated nanofaceted-Si

This work deals with tunable cold cathode electron emission from Au-NP-decorated ensembles of low energy ion-beam fabricated silicon nanofacets (Si-NFs) having fascinating ultralow turn-on field (as low as 0.27 V μm^{-1}) and remarkably low threshold electric field (as low as 0.37 V μm^{-1}) with outstanding stability and extremely high field enhancement factors. It is interesting to note that even as-prepared Si-NFs offer hitherto unseen low turn-on field (as low as 0.58 V μm^{-1}) and threshold electric field (0.66 V μm^{-1}) - so far silicon-based nanostructures are concerned. Kelvin probe force microscopy studies reveal that tunablity in work function of Au-NP-decorated Si-NF samples depends on dimension and growth-angle of Au-NPs. In addition, in-depth dual pass tunneling current microscopy measurements demonstrate that Au-NPs on apexes and sidewalls of Si-NFs act as cold cathode electron emission sites which help to improve the turn-on and threshold fields for Au-NP-decorated Si-NFs in comparison to their as-

prepared counterparts where electron emission takes place mostly from their sidewalls and valleys. Further, finite element electrostatic field-based simulations reinforce the experimental observations. The present investigations paves the pathway to fabricate self-organized Si nanostructure-based highly stable cold cathode electron emitting devices having fascinating low turn-on and threshold fields along with and high stability for use in nanoscale electronic devices.

(Prof. T. Som)

iii. Tailoring magnetic anisotropy in Co thin films on nanowire-like patterned-Ge substrates

This work deals with the influence of growth angle on morphology and uniaxial magnetic anisotropy of magnetron sputter-deposited cobalt films on patterned-Ge substrates (having nanowire-like morphology with extreme regularity) prepared by keV Au-ion bombardment at room temperature. Morphological studies reveal that grain size in Co films increases with increasing growth angle, albeit lateral spacing among the ridges of conformally grown Co films (under growth angles in the range of 0-70°) on patterned-Ge substrates match quite well with that of a patterned-Ge substrate. While an increase in the Co grain size is expected to cause higher coercive fields, in the presence of magnetic pinning and slopes between ridges and grooves of nanowire-like patterned Co morphology, we observe an inverse trend. In other words, an increase in the grain size in conjunction with respective evolution of microstructures in Co films, at higher growth angles, lead to a decrease in the coercive field. Magnetic force microscopy is employed to probe the out-of-plane domains in ferromagnetic Co films. Tailored design of these novel nanostructured Co layers will be of interest for fabrication of high-density magnetic data storage devices, magneto-transport phenomena, and magneto-plasmonics.

(Prof. T. Som)

C. Growth and characterization of thin films for hole-blocking photovoltaic cells

i. Thin film growth using radio-frequency magnetron sputtering

We are studying growth and characterization of thin films of transparent conducting oxides, hole-blocking oxides, 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.

(Prof. T. Som)

ii. Study on optoelectronic properties of zinc-doped tin oxide (ZTO) thin films

In this case, we have studied the tunablity in work function, electrical, and optical properties of ZTO thin films which is a promising transparent conducting oxide material and suitable for use as a window layer in CdTe-based solar cells. Using Kelvin probe force microscopy, we demonstrate that local work function of amorphous ZTO films can be tuned from 5.04 to 4.94 eV by varying the film thickness from 60 to 240 nm, while the average grain size increases (from 24 to 58 nm) with increasing film thickness. In addition, systematic red shift in the band gap and a decrease in the resistivity take place with

increasing thickness. Current-voltage characteristics show a systematic reduction in the turn-on potential and an enhancement in the leakage current with increasing ZTO film thickness. Above observations are explained in the framework of ZTO thickness-dependent variation in the grain size

(Prof. T. Som)

iii. Hole-blocking property of MoOx thin films

We have studied the hole-blocking properties of MoOx layers for their applications in photovoltaic cells. In doing so, the role of growth angle on the optoelectronic properties of sputter deposited MoOx thin films are investigated. Compositional analyses show that oxygen vacancy in MoOx films increases up to a growth angle of 50°, whereas it decreases for films grown at even higher growth angles. Following this, Kelvin probe force microscopy is employed to determine the work function of MoOx films which shows an opposite trend. Further, current-voltage characteristics confirm the rectifying behaviour of all MoOx/Si heterojunctions, whereas the one corresponding to MoOx film grown under normally incident deposition flux shows the lowest leakage current. We have also studied thickness-dependent hole-blocking property of MoOx layer. The present results demonstrate that MoOx films grown under normally incident flux will be very much suitable for constructing a hole-blocking photovoltaic cells using CdTe as an absorber layer.

(Prof. T. Som)

iv. Growth of $SbSe_3$ thin films as an absorber layer for photovoltaic cells

In thin film photovoltaics, antimony selenide (Sb_2Se_3) is making a mark as an important absorber layer for its attractive structural, optical, and electrical properties. Recently, we have investigated the roles of growth angle (in the range of 0°-87°) and thickness (250 and 1000 nm) in governing optoelectronic properties of Sb_2Se_3 films grown by radio frequency sputter deposition technique. It is interesting to note that upon increasing the growth angle, a systematic enhancement in the optical band gap takes place. This is accompanied by a systematic reduction in the work function of these amorphous films with increasing growth angle. Subsequently, after post-growth annealing at 573 K for 180 s (in vacuum) all Sb_2Se_3 films undergo a structural phase transition from amorphous to crystalline one. Following this, the band gap and work function of these films also get modified. This study paves the way to fabricate Sb_2Se_3 films having tunable optoelectronic properties like absorption coefficient, band-gap, and work function.

(Prof. T. Som)

v. Growth of textured semiconductor substrates for photovoltaic cells

We are also fabricating textured semiconductor materials by chemical etching for fabricating hole-blocking photovoltaic cells having same layered configuration. For instance, anisotropic alkaline etching of single crystalline *p*-Si(100) substrates is carried out for different times (in the range of 30-2400 s). This leads to the formation of randomly distributed pyramidal structures on Si surfaces (having dimensions in the range of 0.2-2μm). The formation of pyramidal structures is explained in light of simulation studies based on the continuum theory of stress-induced morphological instability. Following

this, we study the temporal evolution of antireflection property of such pyramidally textured-silicon substrates in line with their potential use in solar cells. For instance, it is interesting to note that surface reflectance of these pyramidally textured surfaces (formed at higher etching times) can be brought down to as low as 0.4% over a broad spectral range, viz., 300-3000 nm. Similar exciting anti-reflection properties are observed for pyramidally textured-germanium substrates under metal-assisted chemical etching which are going to be used for growing Sb_2Se_3 absorber layer-based photovoltaic cells.

(Prof. T. Som)

D. Resistive switching behavior of oxide thin films for potential applications in neuromorphic computing

i. Neuromorphic computing

Neuromorphic computing (or brain-inspired computing) is a promising concept for processing enormous information even at low-power, energy-efficient spiking networks 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, which can faithfully emulate at device level by using a two-terminal memristor-known as "artificial synapse". 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 in this area using several oxide thin films.

(Prof. T. Som)

ii. Tunable resistive switching in TiOx for artificial synapse

In our recent work, we have investigated the role of 5 keV Ar-ion implantation on resistive switching property of pulsed laser deposited (PLD) TiO_x thin films. It is interesting to note that as-grown films do not show RS behavior, albeit after implantation, TiO_x films do exhibit RS property beyond a threshold fluence of 1×10^{15} ions cm^{-2}. Our results show that upon increasing the ion fluence, an enhanced data storage capability can be achieved, through lowering of the SET/RESET voltages, with a good stability (up to 100 switching cycles). We further demonstrate a gradual modulation in the device current by applying electrical pulses which remains completely stochastic in nature upon progression. Our results demonstrate that TiOx-based memristors (or artificial synapses), having tunable RS behavior very useful for application in neuromorphic computing systems.

(Prof. T. Som)

iii. Morphology-driven improved bio-synaptic behavior of Au-ion implanted TiO_x thin films.

In this work, we demonstrate fluence-dependent evolution of anisotropic ripple

morphology on Au-ion implanted TiOx surface which leads to anisotropic RS property (probed from the grooves and ridges of the ripple patterns).In particular, we demonstrate morphology-dependent evolution of anisotropic surface current using conductive atomic force microscopy (cAFM) technique. Most of the bio-synaptic behaviors such as long-term potentiation (LTP), long-term depression (LTD), spike-rate-dependent and spike-timing-dependent plasticity, paired-pulse facilitation (PPF), and post-tetanic potentiation (PTP) have been successfully achieved in Au-ion implanted TiO_x with an ion fluence of 1×10^{17} ions cm^{-2}. To the best of our knowledge, this is the first ever attempt to use AFM for pulsing and probing the capability of gradual resistance modulation in a memristive device to explore its potential application in neuromorphic computing.

(Prof. T. Som)

iv. A highly stable nanoscale artificial nociceptor

Based on cAFM studies, we demonstrate an artificial nanoscale nociceptor built upon a simple Au-ion implanted, two terminal TiO_x memristor. Nanoscale current-voltage characteristics of Pt/TiOx/p++-Si device (probed by cAFM) show a highly stable loop opening which is attributed to charge trapping/detrapping on TiO_x surface. It is observed that device output current changes with increasing number of input electrical pulses under self-biased condition and this feature is used to design the artificial nociceptor. For instance, electrical stimuli-induced nociceptive phenomena such as threshold, relaxation, allodynia, and hyperalgesia are found to be present in Au-ion implanted TiO_x devices. The present study provides a unique platform to design highly stable and reproducible nanoscale electronic artificial nociceptors for developing humanoid robots.

(Prof. T. Som)

v. A transparent photonic artificial visual cortex

Mimicking brain-like functionality with an electronic device is an essential step toward the design of future technologies including artificial visual and memory applications. Here, a proof-of-concept all-oxide-based (NiO/TiO_2) highly transparent heterostructure is proposed and demonstrated which mimics the primitive functions of the visual cortex. Specifically, orientation selectivity and spatiotemporal processing similar to that of the visual cortex are demonstrated using direct optical stimuli under the self-biased condition due to photovoltaic effect, illustrating an energy-efficient approach for neuromorphic computing. The photocurrent of the device can be modulated over a wide range and the device shows fast rise and fall times as well. Based on Kelvin probe force microscopy (KPFM) measurements, the observed results are attributed to a lateral photovoltaic effect.

(Prof. T. Som)

vi. Direct evidence of short- and long-term memories in transparent artificial bio-synapses

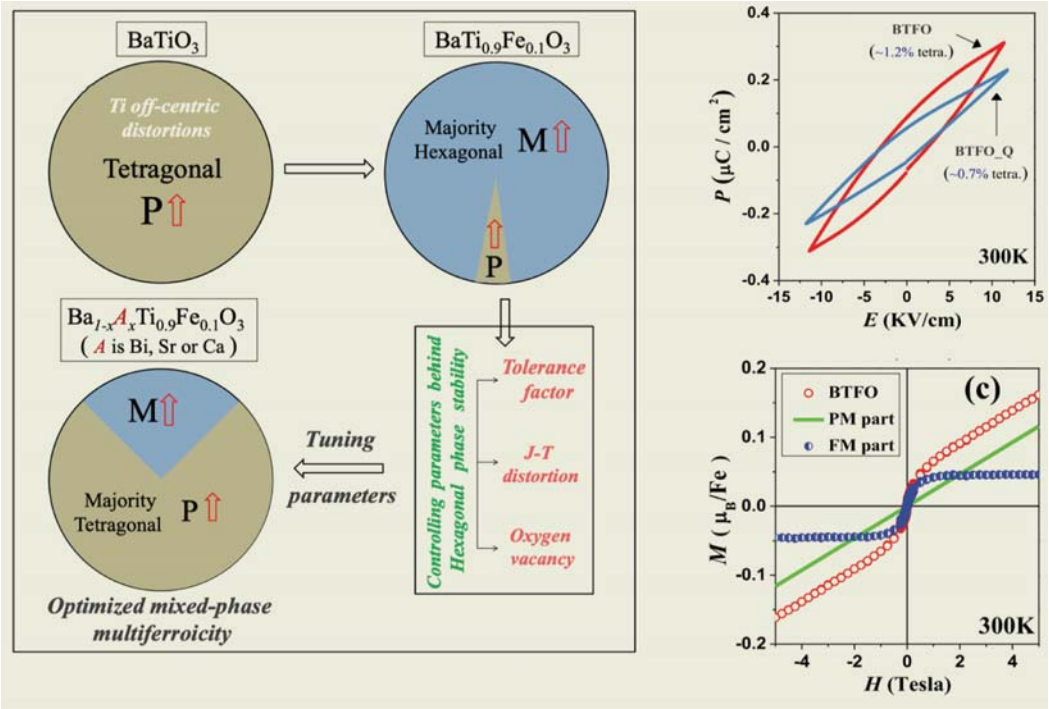
Short-term and long-term plasticity of bio-synapses are thought to underpin critical physiological functions in neural circuits. In this report, we vividly emulate the short- and long-term synaptic functions in a single TiO_x/ITO

memristor using cAFM. The device demonstrates remarkable nanoscale resistive switching property with comprehensive synaptic functions including short-to-long-term memory, spike-rate-dependent plasticity, paired-pulse facilitation (PPF), and post-tetanic potentiation (PTP). The dynamic processes of memorizing (i.e. LTM) and forgetting (i.e. STM) are mimicked through a 3×3 memristive synapse array. The present study provides a unique pathway to fabricate high-performance and reproducible nanoscale artificial synapses for brain-inspired computing systems.

(Prof. T. Som)

5. A. Origin and tuning of room-temperature multiferroicity in Fe-doped $BaTiO_3$

Simultaneous coexistence of room-temperature ferromagnetism and ferroelectricity in Fe-doped $BaTiO_3$ (BTO) is intriguing, as such Fe doping into tetragonal BTO, a room-temperature ferroelectric, results in the stabilization of its hexagonal polymorph which is ferroelectric only below ~80K. We investigate its origin and show that Fe-doped BTO has a mixed-phase room-temperature multiferroicity, where the ferromagnetism comes from the majority hexagonal phase and a minority tetragonal phase gives rise to the observed weak ferroelectricity. In order to achieve majority tetragonal phase (responsible for room-temperature ferroelectricity) in Fe-doped BTO, we investigate the role of different parameters which primarily control the paraelectric hexagonal phase stability over the ferroelectric tetragonal one and identify three major factors, namely the effect of ionic size, Jahn-Teller (JT)



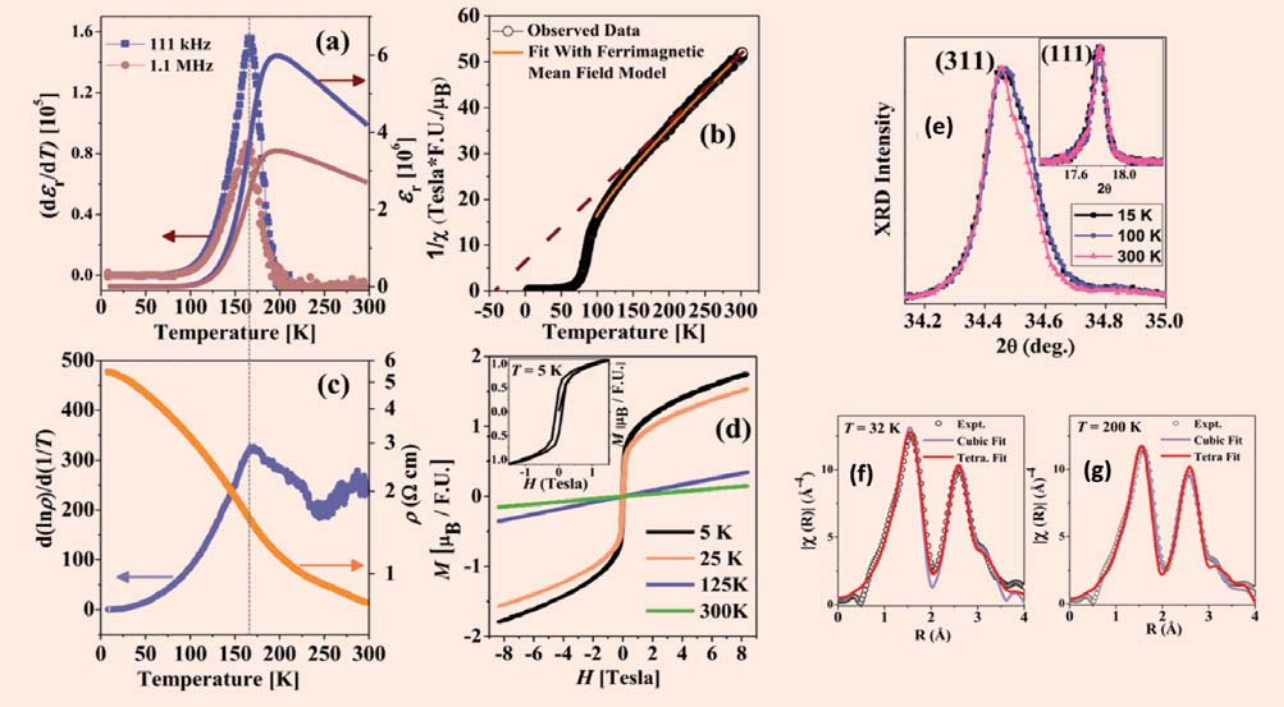
A. Schematic representation of room-temperature mixed phase multiferroicity in Fe-doped BTO: BTFO (b) Comparison of room-temperature P-E loops of BTFO and BTFO_Q, (c) Decomposition of room-temperature M-H plot into paramagnetic and ferromagnetic parts.

distortions, and oxygen-vacancies, to be primarily responsible. The effect of ionic size which can be qualitatively represented using the Goldschmidt's tolerance factor seems to be the major dictating factor for the hexagonal phase stability. The understanding of these factors not only enables us to control them but also to achieve a suitable codoped BTO compound with enhanced room-temperature multiferroic properties.

(D. Topwal)

B. Tetramer orbital ordering and lattice chirality in $MnTi_2O_4$

In transition-metal oxides with strong electron-electron correlations, electrons are primarily localized on the atoms. Exotic physics ensue when such localized electrons also possess orbital degrees of freedom, i.e., electrons can choose to occupy between a set of equivalent and energy-degenerate atomic orbitals. Octahedrally coordinated Mn^{3+} ions in $LaMnO_3$ with $3d^4$ (t^3_{2g}-e^1_g) configuration constitutes a representative example, where a single electron has a choice to occupy any of the two degenerate eg orbitals. Often at a lower temperature, te electron chooses one from the two eg orbitals, which breaks the local charge symmetry and is accompanied by differential oxygen-ion displacements, referred to



Temperature (T) dependencies of (a) dielectric constant (ε_τ) and $d\varepsilon_\tau/dT$, (b) inverse susceptibility ($1/\chi$) (the solid line is a fit using a mean-field ferrimagnetic model and the dashed line is a guide to the eye), (c) resistivity (ρ) and d lnρ d(1/T) of $MnTi_2O_4$. (d) Isothermal M-H curves measured at 5, 25, 125, and 300 K with the inset showing an expanded view of the hysteresis loop at 5 K. (e) Broadening of (311) x-ray diffraction (XRD) peaks measured at T = 15 and 100 K with respect to that measured at T = 300 K. Inset shows that similar T -dependent broadening is not observed for (111) XRD peak. Comparative fittings of Ti-K-edge EXAFS oscillations at (f) T = 32 K and (g) 200 K with tetragonal and cubic structures.

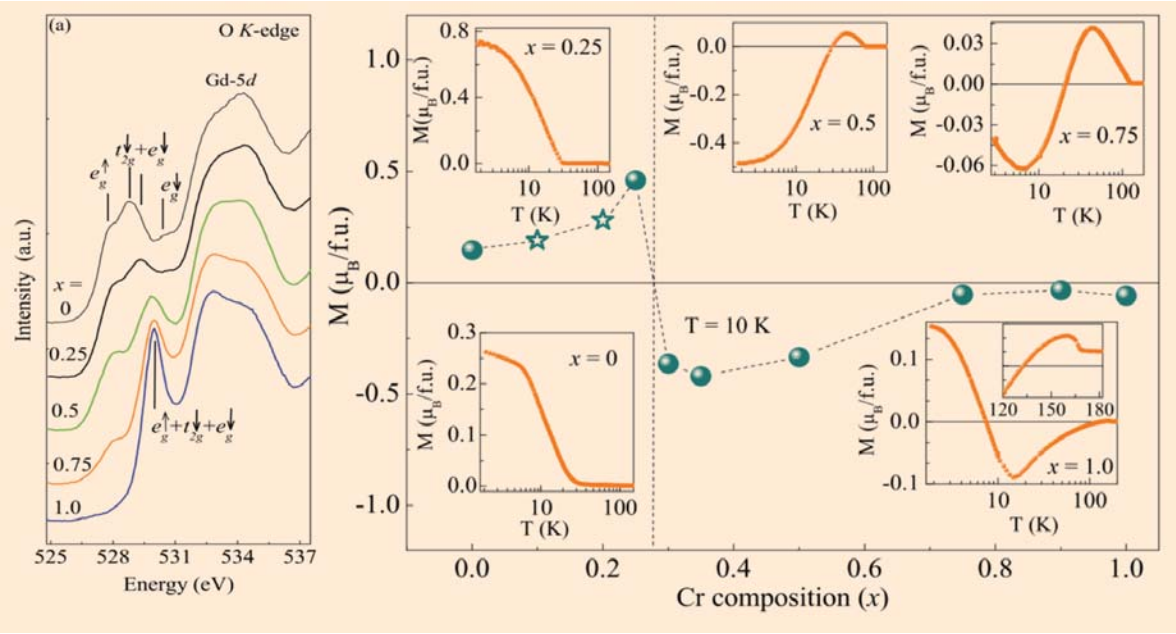
as JahnTeller (JT) distortion. In a solid, such choices on different atoms are interdependent, which results in cooperative JT distortions associated with a spontaneous orbital-ordering transition, wherein localized occupied orbitals on various ions form a regular pattern. We use a combination of density-functional theory calculations and various experimental investigations to reveal a unique ground state for a Ti^{3+} containing spinel oxide, $MnTi_2O_4$, which hosts an exotic combination of a rare tetramer orbital (associated with Ti^{3+} $3d^1$ electron) ordering along equivalent 111 directions involving all three t2g orbitals, a ferrimagnetic Mn-Ti, and a ferromagnetic Ti-lattice spin ordering. A combination of spin-orbital superexchange and JT-effect related strain-energy optimization provides a microscopic understanding for the stabilization of the unique ground state, which is found to be also electrically polar. The tetramer orbital ordering induces Ti-Ti bond length modulations and the short and long Ti-Ti bonds form helices around the crystallographic c axis with a particular winding direction, causing the ground state structure to become spatial chiral.

(D. Topwal)

C. Site-substitution in $GdMnO_3$: effects on structural, electronic and magnetic properties

The rare-earth manganites ($RMnO_3$) invoked great interest owing to the JahnTeller (JT) character of Mn^{3+} ions (t^3_{2g}-e^1_g), exhibiting orbital ordering along with highly anisotropic Mn-O bond lengths. A complex interplay among the spin, orbital and lattice degrees of freedom has led to a large number of intriguing physical properties in such as colossal magnetoresistance, charge and orbital ordering, metal- insulator transition, complex spin structures, multiferroic properties with significant magnetoelectric coupling. In contrast to Mn^{3+}, Cr^{3+} is JT inactive ion because of having completely empty eg orbitals. We studied detailed structural, electronic and magnetic properties of $GdMn_{1-x}Cr_xO_3$ for Cr doping levels $0 \leq x \leq 1$. In the solid solutions, the JT distortion associated with Mn3+ ions gives rise to major changes in the bc-plane sub-lattice and also the effective orbital ordering in the ab-plane, which persist up to the compositions $x \sim 0.35$. These distinct features in the lattice and orbital degrees of freedom are also correlated with bc-plane anisotropy of the local Gd environment. A gradual evolution of electronic states with doping is also clearly seen in O K-edge x-ray absorption spectra. Evidence of magnetization reversal in field-cooled- cooling mode for $x \geq 0.35$ coinciding the JT crossover, suggests a close correlation between magnetic interaction and structural distortion. These observations indicate a strong entanglement between lattice, spin, electronic and orbital degrees of freedom. The nonmonotonic variation of remnant magnetization can be explained by doping induced modification of magnetic interactions. Density functional theory calculations are consistent with a layer-by-layer type doping with ferromagnetic (antiferomagnetic) coupling between Mn (Cr) ions for intermediate compound ($x = 0.5$), which is distinct from that observed for the end members $GMnO_3$ and $GdCrO_3$.

(D. Topwal)



(a) Evolution of O K-edge XAS spectra with compositions (x) in $GdMn_{1-x}Cr_xO_3$ (x = 0, 0.25, 0.5, 0.75 and 1.0). (b) Variation in magnetic moment at 10 K with compositions (x) in $GdMn_{1-x}Cr_xO_3$. Insets represent temperature dependent magnetization measured in field-cooled-cooling protocol for various concentration of (x).

D. Probing the Electronic Structure of Hybrid Perovskites in the Orientationally Disordered Cubic Phase

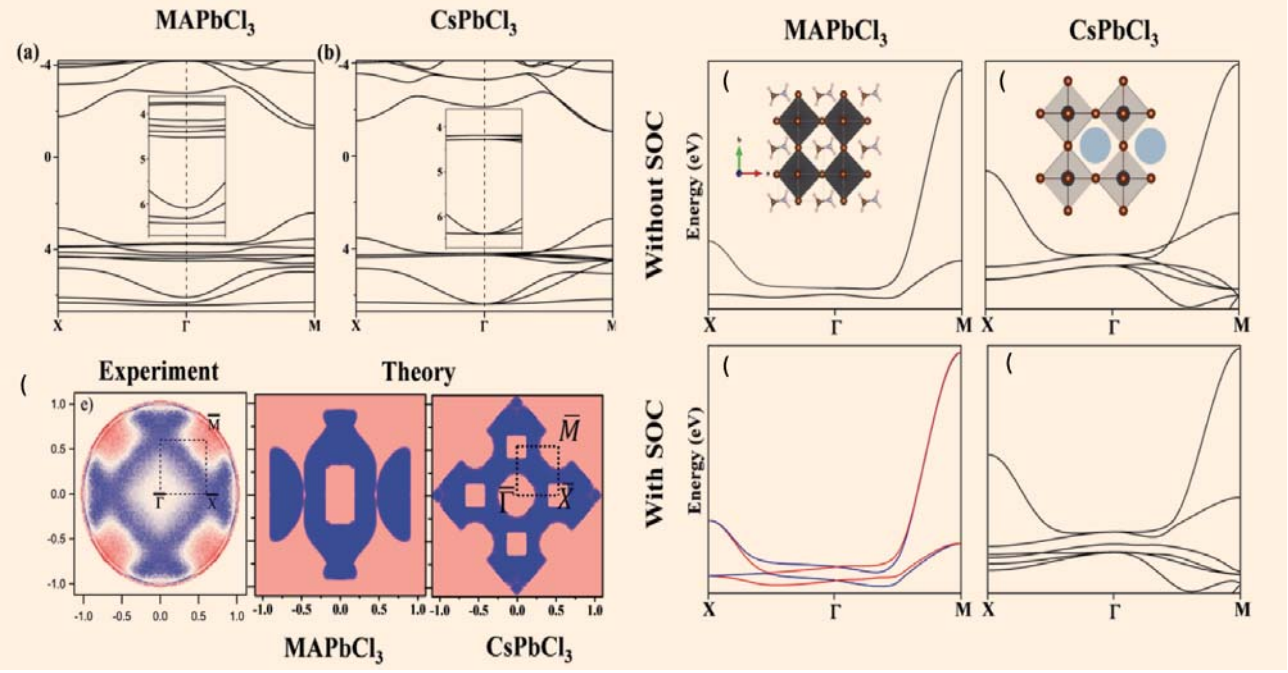
Organic-inorganic halide perovskites, of the type $MAPbX_3$, ('MA' = CH_3NH_3 i.e. methylammonium and 'X' = Cl, Br and I) are one of the most widely investigated class of systems for photo-voltaic applications due to their strong light absorption ability coupled with the ease and low cost of fabrication. Further, their excellent performance in a solar cell, with above 25% efficiency, almost at the level of commercially available silicon cells, has stimulated considerable interest to understand the photo-physical properties of these systems. However, fundamental questions concerning their electronic structure, importance of spin-orbit coupling, and the effect of orientational disorder on their electronic structures are not well understood. It is known that the organic cations MA^+ do not contribute directly to the electronic states near either the highest valence or the lowest conduction bands, which contribute predominantly to the charge carriers. However their orientation in the crystal strongly influences the optoelectronic properties. Changing MA^+ orientation from (100) to (111) direction has profound effect on the electronic structure, namely the bandgap changes from direct to indirect. Further, it is observed that the orientational dynamics of the MA^+ ion inside the PbX_6 octahedral cage is responsible for strong frequency dependence of the relative permittivity, reduction of the Fröhlich electron-phonon coupling and reduction in the thermal stability of the hybrid perovskites. To obtain a deeper understanding of the electronic structure, valence band dispersions were measured using angle-resolved photoemission spectroscopy on two prototypical samples ($MAPbBr_3$ and

$MAPbCl_3$) in the cubic phase and the results were compared with the calculations within two theoretical models where MA^+ is orientationally (1) disordered (MA^+ ion is replaced by spherically symmetric Cs^+ ion) and (2) ordered (MA oriented along (100) direction) but keeping the symmetry of the unit cell cubic. Degeneracy of the valence bands and behavior of constant energy contours obtained from experimental photoemission study are consistent with Model (1) which supports the strongly disordered nature of the orientation of the MA^+ ions in the cubic phase. Careful inspection of the band structure obtained from the first-principle calculations also reveals that spin-orbit coupling induced Rashba splitting is suppressed by the orientational disorder.

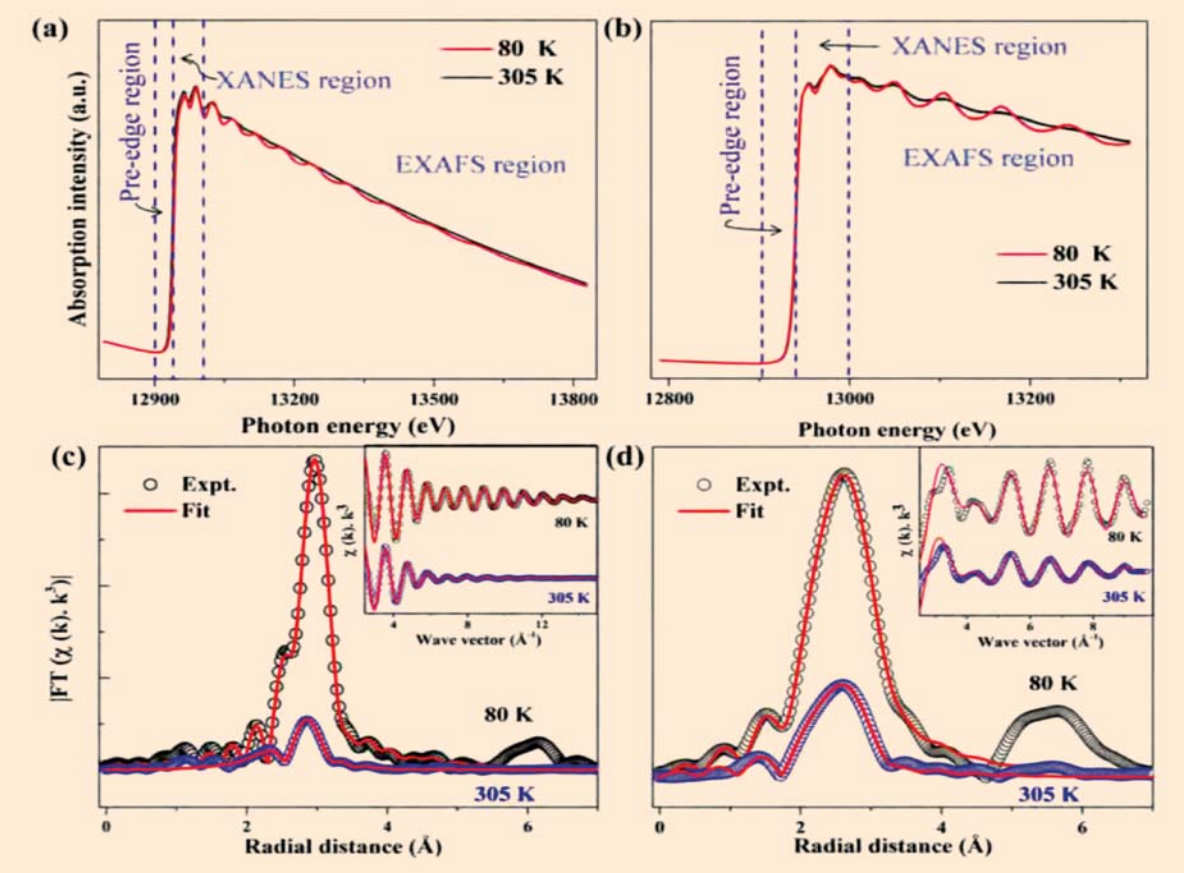
(D. Topwal)

E. Local structural analysis: of Hybrid perovskites ($CH_3NH_3PbX_3$)

Based on temperature dependent X-ray diffraction studies, it is belived that PbX_6 octahedra exhibits distortions due to off-center displacements of halogen atoms, which might arise because of CH_3NH_3 orientation. For a better understanding, temperature dependent extended x-ray absorption fine structure (EXAFS) measurement were performed. It is a powerful technique which provides information on the local structure around atoms. It provides valuable information about the structural peculiarities and allows us to verify different structural models. Following figures (a) and (b) show the X-ray absorption spectra of $CH_3NH_3PbI_3$ and $CH_3NH_3PbBr_3$ samples from the Pb L_3 edge and corresponding pre-edge, X-ray Absorption Near-



Calculated band structure of (a) $MAPbCl_3$ (Model 2) and (b) $CsPbCl_3$ (Model 1); Inset shows the zoomed view near to point. Calculated topmost valence band of $MAPbCl_3$ without (c) and with (e) spin-orbit coupling (SOC), and of $CsPbCl_3$ without (d) and with SOC (f). Constant energy contours of the electronic structure in the X- I-M plane (g).



XAFS spectrum showing the pre-edge, XANES and EXAFS regions of (a) $CH_3NH_3PbI_3$ and (b) $CH_3NH_3PbBr_3$ samples. Magnitude of Fourier transforms of k^3 - weighted EXAFS data at Pb-L3 edge acquired at 80 K (black open circle) and 305 K (blue open circle) for (c) $CH_3NH_3PbI_3$ and (d) $CH_3NH_3PbBr_3$, along with corresponding fitting superimposed on it (red solid line). Corresponding back-transformed spectra in k-space (open circles) along with fitting are plotted in inset.

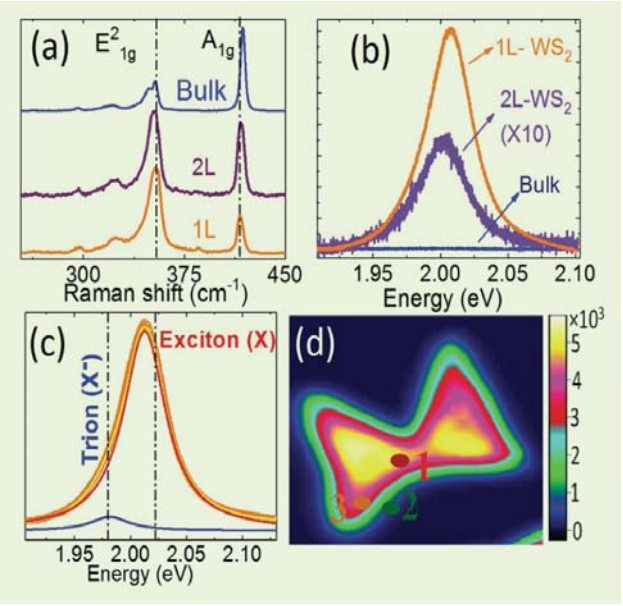
edge Structure (XANES) and EXAFS region are marked in the figure. Our results though in preliminary stage of analysis do point at the PbX6 octahedral distortion across the phase transition

(D. Topwal)

6. A. Manipulation of exciton and trion quasiparticles in monolayer WS_2 via charge transfer

Charge doping in transition metal dichalcogenide is currently a subject of high importance for future electronic and optoelectronic applications. We demonstrate chemical doping in the CVD-grown monolayer (1L) of WS_2 by a few commonly used laboratory solvents by investigating the room temperature photoluminescence (PL). The appearance of distinct trionic emission in the PL spectra and quenched PL intensities suggests n-type doping in WS_2. The temperature-dependent PL spectra of the doped 1L-WS_2 reveal a significant enhancement of trions emission intensity over the excitonic emission at low temperature, indicating the stability of trion at low temperature. The temperature-dependent exciton-trion population dynamic has been modeled using the law of mass

action of trion formation. These results shed light on the solution-based chemical doping in 1L-WS_2 and its profound effect on the photoluminescence which is essential for the control of optical and electrical properties for optoelectronic applications.



Optical characterizations of 1L-WS_2 (a) comparison of Raman spectra of 1L, 2L, and bulk WS_2. (b) Room temperature photoluminescence of 1L, 2L, and bulk WS_2. (c) The PL band is fitted with two peaks, and the low energy and the high energy peaks are denoted as trionic (X-) and excitonic (X) emissions, respectively. (d) Photoluminescence mapping image of two triangular 1L-WS_2 sharing the corner.

Reference: Sahoo et al. Appl. Phys. Lett. 115, 173103 (2019).

(S. Sahoo)

B. Influence of Li ion implantation on LO phonon broadening and bandgap opening in ZnO thin films

Doping of nonmagnetic impurities in technologically important ZnO has opened a new window for achieving room temperature ferromagnetism, p-type carrier conduction, and enhancement of ferroelectric properties. Here, we report on the confined optical phonon and bandgap engineering in highly oriented Li implanted ZnO thin films. Using resonance Raman scattering condition, the confined longitudinal optical phonon lineshapes in uniaxial hexagonal wurtzite crystal are analyzed in detail using the phonon confinement model. We have demonstrated that phonon confinement model can yield a meaningful result for the interpretation of resonance Raman lineshapes if one considers the contribution of both the E_1 (LO) and A_1 (LO) modes, particularly while dealing with oriented ZnO thin films. Furthermore, with the increase in Li dose, the bandgap of ZnO is found to show a blue shift, and such blue shift in bandgap is explained using first principles calculation.

Reference: Sahoo et al. Journal of Alloys and Compounds 806 (2019) 1138-1145.

(S. Sahoo)

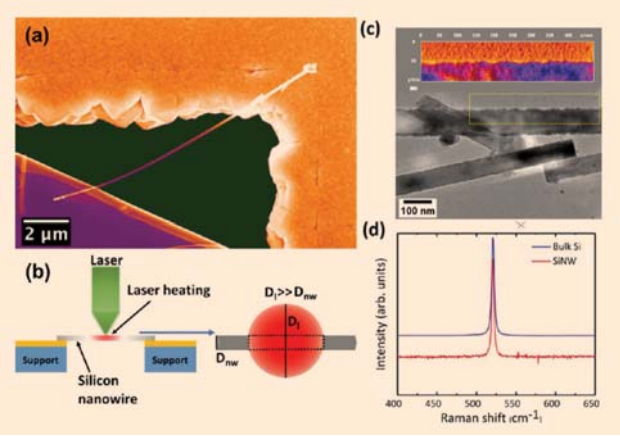
C. Thermal conductivity of free-standing silicon nanowire using Raman spectroscopy

Low dimensional systems, nanowires, in particular, have exhibited excellent optical and electronic properties. Understanding the thermal properties in semiconductor nanowires is very important for their applications in their electronic devices. In the present study, the thermal conductivity of a freestanding silicon nanowire (NW) is estimated employing the Raman spectroscopy. The advantage of this technique is that the light source (laser) can be used both as heating and excitation source. The variations of the first-order Raman peak position of the

freestanding silicon NW with respect to temperature and laser power are carried out. A critical analysis of effective laser power absorbed by exposed silicon NW, the detailed Raman study along with the concept of longitudinal heat distribution in silicon NW, the thermal conductivity of the freestanding silicon NW of 112 nm diameter is estimated to be ~53 W/m.K.

Reference: https://arxiv.org/abs/2002.11540

(S. Sahoo)



(a) False-colored SEM image of a freestanding single silicon NW on TEM grid. (b) Schematic diagram of free-standing single silicon NW (left) and comparison of the dimension of silicon NW, laser spot size (right). The dotted rectangular section shows an effective cross-sectional area of silicon NW exposed to the laser c) TEM image of silicon NW with inset showing the 3-D surface plot of the region bounded by yellow lines. (d) Room temperature Raman spectra of Bulk Si and single silicon NW.

D. The study is on the influence of Ag -ve ion bombardment with different fluences on the microstructural and optical properties of thermally evaporated Bi/$GeSe_2$ bilayer thin films. Two different fluences (5×10^{14} ions cm^{-2} and 1×10^{15} ions cm^{-2}) of Ag -ve ions were used to irradiate the thin films that changed the microstructure and optical properties as studied by different spectroscopic methods like X-ray diffraction method (XRD), Energy dispersive X-ray spectroscopy (EDS), Field emission scanning electron microscopy (FESEM), Atomic force microscopy (AFM), Raman spectroscopy, and UV-Vis spectroscopy. The evolution of topological Bi_2Se_3 phase occurs after ion irradiated diffusion of Bi into $GeSe_2$ matrix. The optical parameters as calculated from the transmission spectra infers the indirect allowed transition with reduction of Eg on ion irradiation. The various optical parameters like absorption coefficient (α), optical energy gap (Eg), Tauc parameter (B1/2), Urbach energy (Ee), extinction coefficient (k), refractive index (n) were modified with ion irradiation. The surface morphology is being changed after irradiation as probed by AFM and FESEM. The Raman spectra support the formation of Bi_2Se_3 phase with irradiation. The obtained results have been explained on the basis of increase in band tailing of valence band due to defect states caused by the irradiation. Appl. Phys. A 126, 203 (2020).

(S. Sahoo)

7. A. Robust weak antilocalization due to spin-orbital entanglement in Dirac material Sr_3SnO

The presence of both inversion (P) and time-reversal (T) symmetries in solids leads to a double degeneracy of the electronic bands (Kramers degeneracy). By lifting the degeneracy, spin textures manifest themselves in momentum space, as in topological insulators or in strong Rashba materials. Non-trivial cases are when the double degeneracy remains in exotic materials. Three-dimensional (3D) Dirac material is a remarkable example of this case, in which spin

could have non-trivial dependence to momentum, but difficult to resolve because all the states are degenerate with time-reversal pairs. Here, we use quantum interference measurements to provide evidence for the existence of hidden entanglement between spin and momentum in the antiperovskite-type Dirac material Sr_3SnO. We find robust weak antilocalization (WAL) independent of the position of EF. The observed WAL is fitted using a single interference channel at low doping, which implies that the different Dirac valleys are mixed by disorder. Notably, this mixing does not suppress WAL, suggesting contrasting interference physics compared to graphene. We identify scattering among axially spin-momentum locked states as a key process that leads to a spin-orbital entanglement.

Reference:

[1] H. Nakamura, D. Huang, J. Merz, E. Khalaf, P. Ostrovsky, A. Yaresko, D. Samal, and H. Takagi, Nature Communications,11, 1161 (2020).

B. Unusual valence state in the antiperovskites Sr3SnO and Sr3PbO revealed by x-ray photoelectron spectroscopy (Physical Review Materials 3, 124203, 2019).

The class of antiperovskite compounds A3BO (A = Ca, Sr, Ba; B = Sn, Pb) has attracted interest as a candidate three-dimensional Dirac system with topological surface states protected by crystal symmetry. A key factor underlying the rich electronic structure of A3BO is the unusual valence state of B, i.e., a formal oxidation state of ?4. Practically, it is not obvious whether anionic B can be stabilized in thin films, due to its unusual chemistry, as well as the polar surface of A3BO, which may render the growth-front surface unstable. We report x-ray photoelectron spectroscopy measurements of single-crystalline films of Sr_3SnO and Sr_3PbO grown by molecular beam epitaxy. We observe shifts in the core-level binding energies that originate from anionic Sn and Pb, consistent with density functional theory calculations. Near the surface, we observe additional signatures of neutral or cationic Sn and Pb, which may point to an electronic or atomic reconstruction with possible impact on putative topological surface states.

Reference:

[1] D. Huang, H. Nakamura, K. Küster, A. Yaresko, D. Samal, N. B. M. Schröter, V. N. Strocov, U. Starke, and H. Takagi, Physical Review Materials 3, 124203 (2019).

C. Dimensionality driven weak antilocalization- weak localisation crossover near metal-insulator transition in $CaCu_3Ru_4O_{12}$ (under review, arXiv: 1908.11128)

Electrons in solids, by coupling with spins and lattices, form dressed particles called quasiparticles (QPs). The mass of such QPs can in some cases be extremely heavy, 100-1000 times the bare electron mass. Heavy-fermionic QP signature is generally found in systems with f-electron systems containing rare earth or actinide ions. In the case of d-electron metals, it is not obvious to identify the same kind of physics. Interestingly certain d transition metal oxides such as LiV_2O_4 and $CaCu_3Ru_4O_{12}$ (CCRO)[1] are reported to exhibit remarkable heavy-fermion

character, and these systems are under investigation to unveil the microscopic underlying physics. If these systems can be made 2D, even more fascinating phenomena are expected to result.

This is because in low spatial dimensions, many-body correlation effects become more prominent and complex. Artificial confinement of electrons by tailoring the layer thickness has turned out to be a powerful tool to harness control over competing phases in complex oxides. In this work, [2] we have successfully fabricated epitaxial CCCRO thin films by Pulsed Laser Deposition (PLD) and study the dimensional effect on its electronic band structure and magneto-transport properties. Transport behavior evolves from metallic to localized regime upon reducing thickness and a metal insulator transition (MIT) is observed below 3 nm (Fig.1) for which sheet resistance crosses h/e^2~ 25 KΩ, the quantum resistance in 2D. A delicate interplay between inelastic and spin-orbit scattering lengths (Fig.1) close to metal insulator transition is observed which could result in a negative to positive magnetoconducatance crossover upon reducing film thickness. Band structure analysis reveals structural distortion that augments the strong correlation effect with reduced film thickness. Further studies are underway to estimate the the dimensionalty effect on effective mass and to understnd the interplay beteween electron corrletion and spin-orbit cupling in the observed negative magntoconductance beahviour.

References:

[1] W. Kobayashi et al., J. Phys. Soc. Jpn. 73, 2373,2004 and A. Krimmel et al., Phys. Rev. B 78, 165126 (2008).

[2] Evidence for Dimensionality driven weak antilocalization-weak localisation crossover near metal-insulator transition in $CaCu_3Ru_4O_{12}$, Subhadip Jana, Shwetha G.Bhat, B.C.Behera,

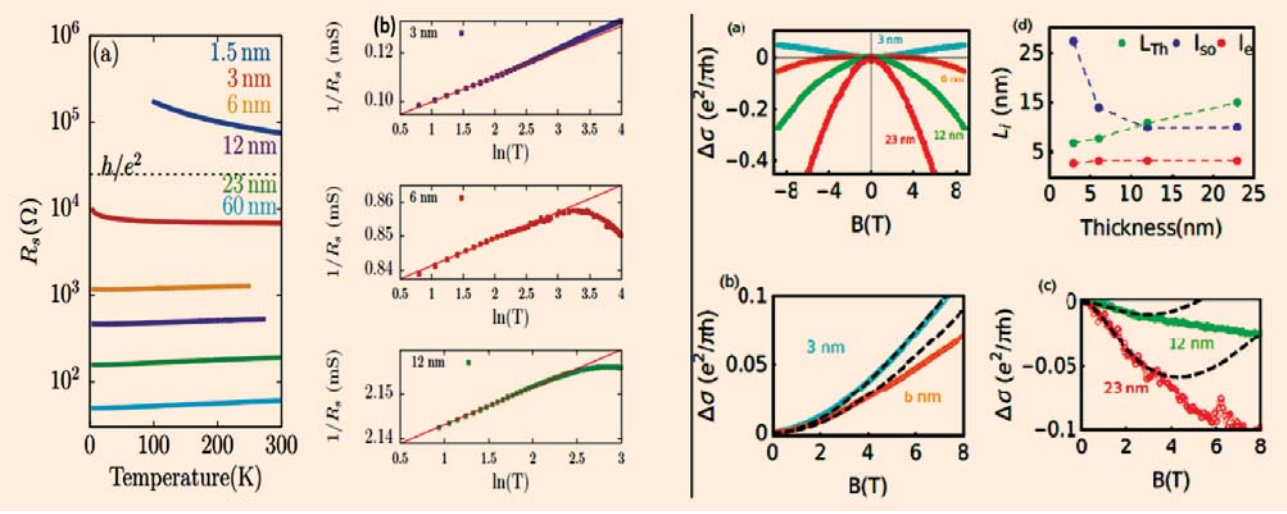


Fig.1: **Left panel** (a) CCRO film thickness dependent Sheet Resistance (Rs) *vs* temperature showing MIT (b) 1/Rs vs ln (T) plots for films of various thickness indicating quantum interference effect. **Right Panel** (a) Magnetoconductance measured for films of different thickness at 2K (including classical B^2 contribution). (b) and (c) fitting with HLN equation (dashed black lines) after subtracting B^2 contribution from experimental data. (d) inelastic (L_{Th}), spin-orbit (l_{so}), and elastic (l_e) lengths extracted from fits.

L.Patra, P.S.Anil Kumar, B.R.K.Nanda, D. Samal (under review)

D. Interplay between spin-orbit interaction and electron correlation in in $CaCu_3Ru_4O_{12}$ (manuscript in preparation)

$CaCu_3Ru_4O_{12}$ is a debated as a rare class of 4d electron based heavy fermionic system with intriguing properties.[1] Magntoconductance measurement on CCRO single crystalline thin-flms in 2D limit features weak-antilocalization effect which could arise due to spin-orbit interaction and/or electron correlation. Analysing magneto conductance data with established weak-localization and weak-antilocalization theory in the presence of correlation effects, relative strength of spin-orbit and electron-electron correlation is figured out in $CaCu_3Ru_4O_{12}$.

References

[1] W. Kobayashi et al., J. Phys. Soc. Jpn. 73, 2373,2004 and A. Krimmel et al., Phys. Rev. B 78, 165126 (2008)., (D. Samal)

E. Tailoring the magnetic properties of spinel vanadate epitaxial CoV_2O_4 thin films (manuscript in preparation)

Spinel vanadates, in which itinerancy and frustration can be controlled via manipulation of the V-V distance are poster materials for orbital physics in frustrated antiferromagnets. CoV_2O_4 has attaracted a lot of attention attention because it is identified as a material close to localized-itinerant cross-over[1]. Bulk cubic CoV_2O_4 shows orbital degeneracy down to very low temperatures, with only small anomalies in magnetization and neutron experiments signaling a possible spin/orbital glass transition at T = 90 K[2]. The proximity to itinerancy has been indicated as the cause for the difficulties in observing these transitions. In contrast to the weak effects seen in cubic bulk samples, recently orthorhombic CoV_2O_4 thin films grown on $SrTiO_3$ substrates displays prominenet signatures of spin canting and structural effects that possibly indicate long-ranged orbital order [3]. However a comprehensive understnding of magntic properties of the orthorhombic CoV_2O_4 thin films and how it changes when the films are subjected to epitaxial strain (compressive as well as tensile) and dimensionalty is lacking in the literature.

CoV_2O_4 (CVO) thin films grown on $SrTiO_3$ (001) substrates. Structural investigation (Fig.2) finds that the orthorhombic CoV_2O_4 thin films grows epitaxially on STO substrate. From magnetic measurements, we observe a magnetic transition (spin re-orientataion transition (TSR)) as marked by arrows towards low temperature side in addition to bulk like ferrimagntic transition at TC ~150K as reported recently by Christie J. Thompson et al.[3] The in-plane and out of plane temperature dependent magnetization shows distinct behavior (in-plane magnetization increases below second transition whereas out of plane magnetization decreases). We conjecture at this point of time that there exists an in-plane ferromagnetic coupling between the sublattices of V^{3+} and Co^{2+} ions, whereas there exists an out of plane antiferromagnetic coupling below the second transition. Similarly, the M-H hysteresis at 2K (not shown here) also exhibits higher magnetisation value for in-plane and a lower

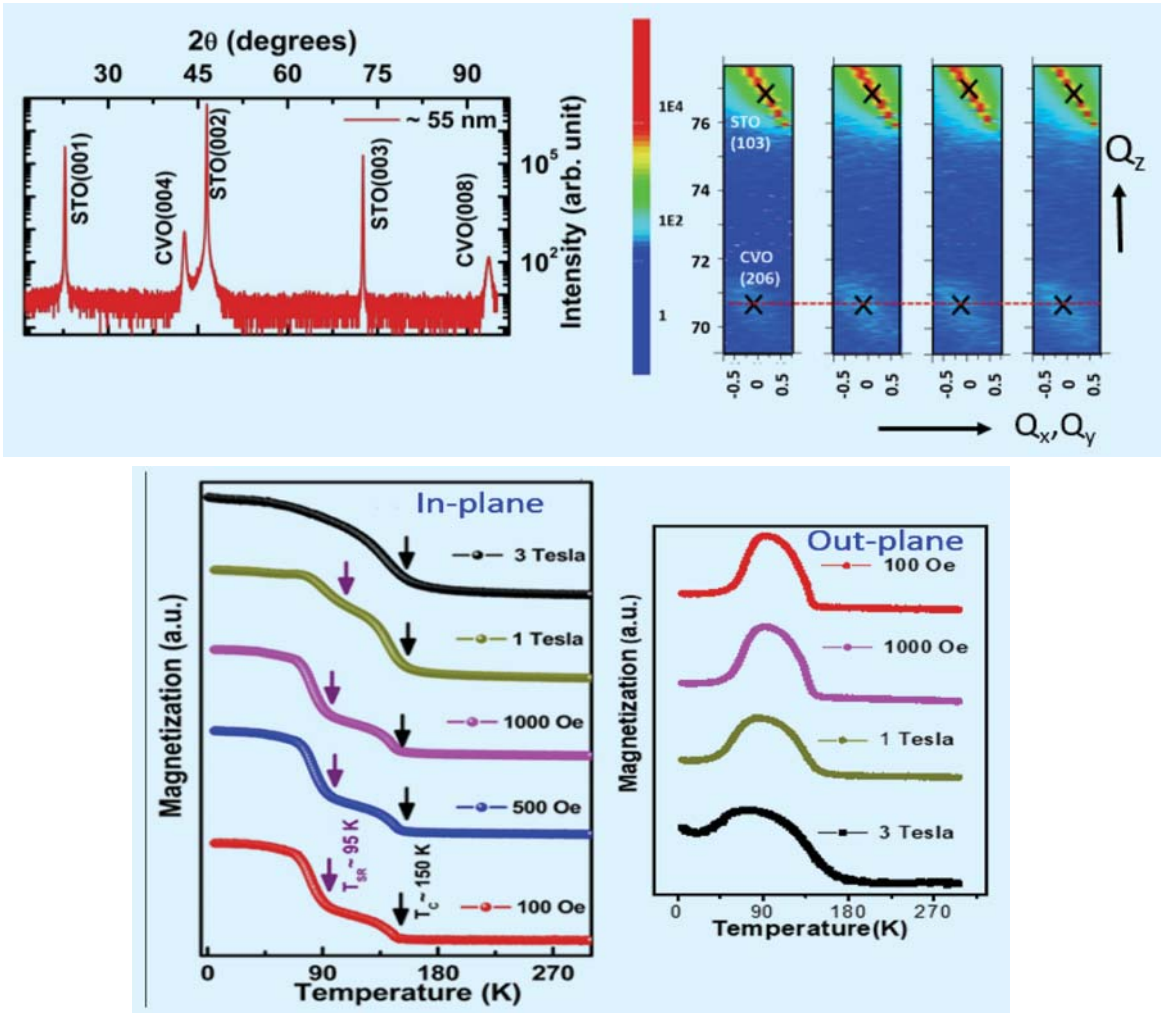


Fig.2: Top panel: (**Left)** θ-2θ x-ray diffraction pattern for ~ 55 nm orthorhombic CVO film on STO. (**Right)** Reciprocal space mapping about 4 symmetric planes of STO (103) indicating no crystal distortion **Bottom panel**: (**Left)** Field cooled in-plane magnetization. (**Right)** Field cooled out of plane magnetization.

value for the out of plane orientataion. Strikingly, in-plane M-H- loop exhibits a two-step behaviour which could be due to two different magnetic sublattices, which are not strongly coupled along the in-plane direction. A comprehensive study with varying lattice strain by using various substrates such as MgO and TiO2, and dimensionality are in progress to delve into the microscopic understanding for the emergence of low temperature magnetic transition as well as the electronic structure of CoV_2O_4 thin films.

References:

[1] A. Kismarahardja et al., Phys. Rev. Lett. 106, 056602 (2011).

[2] D. Reig-i-Plessis et al., Phys. Rev. B 93, 014437 (2016) and R. Koborinai et al., Phys. Rev. Lett. 116, 037201 (2016)

[3] Christie J. Thompson et al., Phys. Rev. Materials 2, 104411 (2018)

(D. Samal)

F. Exploring local geometry and magnetism in $Ni_{1-x}Cu_xO$ (manuscript in preparation)

Many properties in complex oxides originate from their local structure characteristics. In this work, we examine the local lattice geometry of cubic $Ni_{1-x}Cu_xO$ ($0 \leq x \leq 0.2$) using extended x-ray absorption fine structure (EXAFS) techniques and first-principles calculations. EXAFS analysis suggests that Cu in $Ni_{1-x}Cu_xO$ adopts a closer to six-fold octahedral oxygen coordination, unlike the case for cooperative Jahn-Teller distorted monoclinic-CuO in which Cu is four-fold coordinated. The CuO6 octahedra surrounding the Cu^{2+} ion, however, undergo local distortions in the oxygen sublattice with inequivalent oxygen sites. We find a change in the local coordination of Cu^{2+} ion but our calculations suggest that an isolated defect model where a Cu atom replaces a Ni atom is not able to quantitatively explain the observed distortion in the local lattice environment of the substitutional Cu impurity in the low concentration regime. Experimental results, on the other hand, agree with our theoretical calculations for higher concentrations where Cu-Cu interaction is taken into account. Furthermore, neutron diffraction studies reveal that the antiferromagnetic structure of NiO remains unchanged upon Cu substitution; nevertheless, the average site ordered moment gets reduced with increasing Cu concentration due to magnetic dilution effect.

(D. Samal)

G. Mixed-valent antimony-induced disorder in substituted antiferromagnetic Mn_2SnS_4

Among $M^{II}{}_2A^{IV}Q_4$ (M = transition metal; A = Si, Ge, and Sn; Q = S, Se, and Te)-type compounds, most of which crystallize in an olivine or spinel structure, Mn_2SnS_4 is a unique compound that crystallizes in the orthorhombic space group *Cmmm* and exhibits complex magnetic properties. In this article, we report synthesis and study of the effect of Sb substitution (up to 20%) on the magnetic properties of Mn_2SnS_4. All the compounds were found to be in a single phase and indexed with the orthorhombic parent structure. Rietveld refinement of the room-temperature neutron diffraction data of $Mn_2Sn0.85Sb0.15S_4$ sample shows that Sb occupies the Mn site by replacing an equivalent amount of Mn. Subsequently, the replaced Mn occupies the Sn site causing disorder at both the Mn and the Sn sites, and the refined composition $(Mn_{1.85(1)}\ Sb_{0.15(1)})\ (Sn_{0.85(1)}\ Mn_{0.15(1)})\ S_4$ is obtained. Although the purpose of incorporation of Sb(III) was to create a mixed valence state at the Mn site, XPS study shows contrasting results. Sb exists in a mixed valence state, Sb(III) and Sb(V), which balances the charge at the Sn(IV) site. Magnetic study of the compounds shows a very interesting trend. Pure Mn_2SnS_4 shows two magnetic transitions: one at 152 K that corresponds to antiferromagnetic ordering and other at 53 K corresponding to weak ferromagnetic ordering possibly due to spin canting. With antimony substitution, the temperature (152 K) of antiferromagnetic ordering remains unchanged, whereas the temperature of weak ferromagnetic ordering gradually increases with an increase in the Sb content from 53 K for the undoped compound to 88 K for 20% Sb-doped Mn_2SnS_4. The increase in the temperature of weak ferromagnetic ordering could be attributed to the incorporation of Sb, which induces more disorder

at the Mn site, thereby making the magnetic lattice dilute with reduced frustration.

Reference:

Mixed Valent Antimony Induced Disorder in Substituted Antiferromagnetic Mn_2SnS_4,

T. S. Dash, S. D. Kaushik, S. N. Sarangi, D Samal, S. Moun, C. S. Yadav, and S L Samal (Accepted to Dalton Transactions, 2020).

H. Progressive Enhancement of Superconductivity in Mg intercalated 2H-$NbSe_2$ (work in progress)

2H-$NbSe_2$ is known to be an archetype low temperature layered transitional metal dichalcogenide superconductor. We investigate the influence of Mg intercalation on the superconducting properties in $NbSe_2$. The superconducting property sharply depend upon the electronic structure, size, valence, magnetic nature, and electronegativity of intercalating species. Interestingly, we observe that the superconducting transition temperature (Tc) in Mg_xNbSe_2 increases from 6.3 K (x = 0.0) to 6.8 K (x = 0.06) and then decreases from 6.8 K to 6.6 K (x = 0.10) upon higher mole % of Mg intercalation, but remains higher than pristine 2H-$NbSe_2$ (T_c = 6.3 K). A detailed study using various experimental probes and electronic structure calculation is in progress to understand this progressive enhancement of Tc.

(D. Samal)

8. Liquid Crystal Experiments/Simulations

Inhomogeneous formation of topological defects in a phase transition and nature of topological textures in presence of nucleation centers of specific surface properties Setup is being developed for experimentally probing inhomogeneous formation of topological defects in an isotropic-nematic phase transition. In view of the present situation of the pandemic, I am pursuing following project. Utilizing my experience with studying topologically non-trivial patterns (textures) in liquid crystals (experimentally, as well as using simulations), I am developing a code for simulations to see if presence of coronavirus in lyrotropic liquid crystals leads to distinguishing topological textures which can be used for quick detection of infection using simple optical microscope. At IOP I will study it experimentally with nucleation sites of different shapes and surface properties. Plan is to pursue this for the test of coronavirus with faculty at IISER Kolkata.

(Ajit M. Srivastava)

2.6. Theoretical Condensed Matter Physics

At IOP, the condensed matter theory group is 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 the electronic, magnetic and quantum transport properties of various quantum materials.

We are performing an active research in this field with a special emphasis on quantum magnetism and spin liquid physics, strongly correlated electronic systems, quantum entanglement, water and hydrogen bonded systems, quantum transport through various mesoscopic systems, Dirac materials, topological insulator and topological superconductor, Floquet Dirac systems, interplay between topology and correlation etc.

Soft Condensed Matter and Biological Physics

Current activity in this field is mainly focused around developing physical understanding of different biological phenomena. Members are working on the following topics: formation of chromosomal structure, morphology and segregation of E.coli chromosome mediated by protein production and confinement, dynamics of cytoskeletal patterns, phase behavior of active colloids, ratcheting of colloidal dispersion, dynamics of semi flexible polymers in motor protein assay, DNA melting and associated vanishing of rigidity, role of topology in kinetoplast DNA, rheology of soft and active matter, etc.

Statistical Mechanics

The current interest of the group revolves around non-equilibrium stochastic thermodynamics, stochastic heat engines, fluctuation theorem, entropy production by active particles, stochastic pump of interacting particles and current reversal, collective motion driven by molecular motors, etc.

(A. M. Jayannavar, A.M. Srivastava, A. Saha, S. Mandal, D. Chaudhuri)

1. Violation of Leggett-Garg type inequalities in a driven two level atom interacting with a squeezed thermal reservoir:

The violation of Leggett-Garg type inequalities (LGtIs) is studied on a two-level atom, driven by an external held in the presence of a squeezed thermal reservoir. The violations are observed in the underdamped regime where the spontaneous transition rate is much smaller compared to the Rabi frequency. Increase in thermal effects is found to decrease the extent of violation as well as the time over which the violation lasts. With increase in the value squeezing parameter the extent of violation of LGtIs is seen to reduce. The violation of LGtIs is favored by increase in the driving frequency. Further, the interplay of the degree of violation and strength of the measurements is studied. It is found that the maximum violation occurs for ideal protective measurements.

(A. M. Jayannavar)

2. Current carried by evanescent modes and possible device application:

Quantum tunneling of an electron through a classically for-bidden regime has no classical analogue and several aspects of it are still not well understood. In this work we analyze electronic currents under the barrier. For this we consider a multi-channel Aharonov-Bohm ring and develop a correct formalism to calculate the currents inside the ring when the states are evanescent. We also show unlike other pro-posed quantum devices that such currents and associated conductance are not very sensitive to changes in material parameters and thus the system can be used to build stable devices that work on magnetic and transport properties. We also study the current magnification property of the ring in presence of both propagating and evanescent states.

(A. M. Jayannavar)

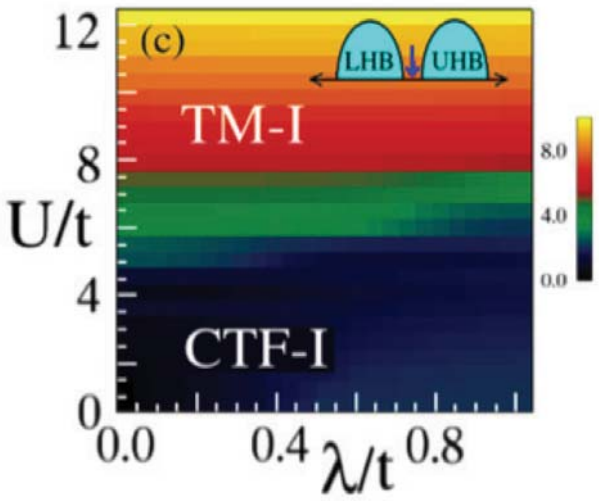
3. "Extreme supercooling with periodically driven pressure, application to superfluids"

Using our earlier results on phase transitions with resonantly driven systems, we are calculating extreme supercooling which can be achieved for a supefluid He^4 system under periodic variation of pressure.

(S.S. Dave, Saumia P.S., and A. M. Srivastava)

- **Interplay of Topology and Correlation in Lieb lattice**

Effects due to strong correlation on bands with non-trivial topology, is an active field of research in modern condensed matter theory. In this work, we investigate the impact of strong correlations on a band topological insulator on the Lieb lattice. The Lieb lattice possesses three bands and, with intrinsic spin-orbit coupling λ, supports topologically nontrivial band insulating phases. At half filling the lower band is fully filled, while the upper band is empty. The chemical potential lies in the flat band (FB) located at the middle of the spectrum, thereby stabilizing a flat band insulator. At this filling, we introduce on-site Hubbard interaction U on all sites. Within a slave rotor mean-field theory we show that, in spite of the singular effect of interaction on the FB, the three bands remain stable up to a fairly large critical correlation strength (U_c), creating a correlated flat band insulator. Beyond U_c, there is a sudden transition to a Mott insulating state,

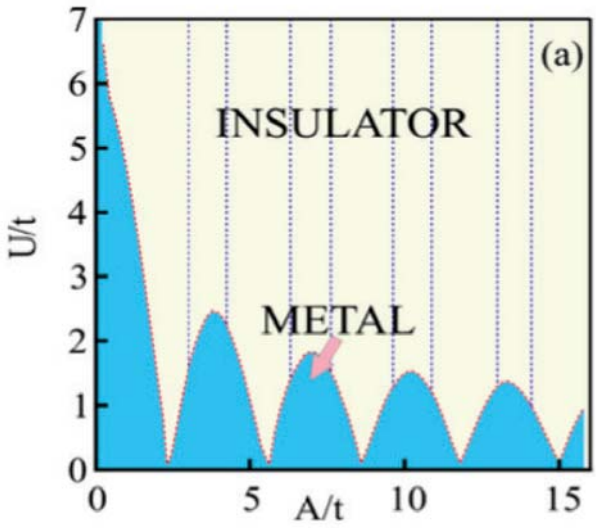


where the FB is destroyed due to complete transfer of spectral weight from the FB to the upper and lower bands. We show that all the correlation driven insulating phases host edge modes with linearly dispersing bands along with a FB passing through the Dirac point, exhibiting that the topological nature of the bulk band structure remains intact in the presence of strong correlation. Furthermore, in the limiting case of *U* introduced only on one sublattice where ë = 0, we show that the Lieb lattice can support mixed edge modes containing contributions from both spinons and electrons, in contrast to purely spinon edge modes arising in the topological Mott insulator.

(Sayan Jana, Anamitra Mukherjee, Arijit Saha)

- **Metal-Insulator Transition in a Periodically Driven Interacting Triangular lattice**

In this 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, the electromagnetic vector potential, with an amplitude A, modifies the bare hopping and generates new next nearest neighbor hopping parameters. For U = 0, the driving acts like an emergent intrinsic spin-orbit coupling term and stabilizes three dispersive Floquet quasi-energy bands with the lower and upper bands exhibiting topological character with non-zero Chern numbers. Within a slave rotor mean field theory, 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 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. In this limit, we show that the external drive provides a handle to engineer periodic band inversions at specific values of A accompanied by topological phase

transitions that are characterized by swapping of band Chern numbers.

(Sayan Jana, Priyanka Mohan, Anamitra Mukherjee, Arijit Saha)

- **Signature of Jackiw-Rebbi zero modes in Topological Insulator Nanowires**

Finding the signature of Jackiw-Rebbi modes in condensed matter systems is an exciting field of research due to their potential applicability in topological quantum computation. In this work, we investigate the emergence of Jackiw-Rebbi zero modes and their conductance signature in non-uniform topological insulator nanowires. We modelled the non-uniform nanowires as the junction between two cylindrical nanowires with different radius. In the limit of wire length being much larger than its radius, the surface state of the nanowire splits into one-dimensional Dirac modes propagating along the axis of the cylinder owing to radial confinement. The sign of the mass gap in each of these Dirac modes is decided by angular momentum quantum number corresponding to the rotational motion of the electron about the axis of the cylindrical nanowires. Application of an external magnetic flux through the cylindrical nanowires enables us to tune the mass gap from positive to negative value across the junction. Due to this flux tunable band inversion, controlled by the external magnetic field, Jackiw-Rebbi zero modes can be made to appear or disappear at the junction. We compute the differential conductance of our topological insulator nanowire junction and show that a quantized conductance peak appears at zero-energy (zero-bias) in the presence of the Jackiw-Rebbi modes.

(Sayan Jana, Sourin Das, Arijit Saha)

- **Higher Order Topological Insulator via Periodic Driving**

Engineering of periodically driven Floquet topological insulators out of a trivial system is a field of interest of its own. In this direction, realization of Floquet higher order topological insulator (HOTI) out of trivial or first order topological systems has become an upcoming frontier area of research. In our work, we theoretically investigate a periodically driven semimetal based on a square lattice. The possibility of engineering both Floquet Topological Insulator featuring Floquet edge states and Floquet higher order topological insulating phase accommodating topological corner modes has been demonstrated starting from the semimetal phase, based on Floquet Hamiltonian picture. Topological phase transition takes place in the bulk quasi-energy spectrum with the variation of the drive amplitude where Chern number changes sign from +1 to -1. This can be attributed to broken time-reversal invariance (t) due to circularly polarized light. When the discrete four-fold rotational symmetry (C_4) is also broken by adding a Wilson mass term along with brokent, higher order topological insulator (HOTI), hosting in-gap modes at all the corners, can be realized. The Floquet quadrupolar moment, calculated with the Floquet states, exhibits a quantized value of 0.5 (modulo 1) identifying the HOTI phase. We show that while for high frequency drive the Floquet corner modes remain pristine at zero energy, dynamic Floquet corner modes arise at quasi-energy $\omega/2$, where ω is the driving frequency, in the intermediate frequency regime.

(Arnob Kumar Ghosh, Ganesh C. Paul, Arijit Saha)

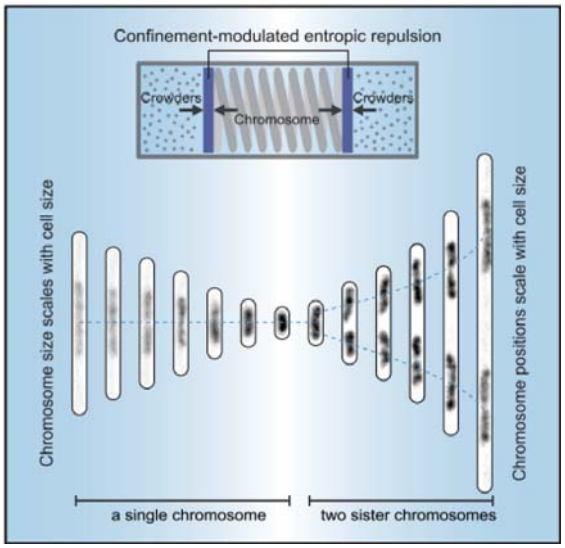
In the year 2019-2020 I mainly worked on five different projects mainly with my students and collaborators. I am briefly describing those. Firstly, we have chart out the finite temperature phase diagram of Squaric Acid systems an we have found existence of ferroelectric phase at low temp, para electric phase at high temp and in intermediate temperature a liquid like quantum paraelectric phase. In our second work we have extended the celebrated two dimensional Haldane model into three dimensional diamond lattice. We have found the existence of a nodal line semi-metal. The low energy effective Hamiltonian has been derived and it is shown to be an asymmetric Weyl semi-metal. The surface states in 111 direction has been calculated which is shown to be gapless and the system belongs to AIII symmetry class. Finally, we have examined the effect of interaction and disorder on Hofstadter spectrum in Square and Honeycomb lattice. We showed that interaction and disorder do nullify each other as expected. The lattice coordination number of the lattice plays an important role as we need stronger disorder or interaction for square lattice to destroy the Hofstadter spectrum. The behavior of entanglement entropy and gap as also investigated. Additionally, we have also examined and make progress on other two project namely the magnetism in Hollandite lattice as well as beam-splitter arrangements in Iron-pnictide materials. The manuscripts are being written presently.

(S. Mandal)

6. Research of the group of Dr. Debasish Chaudhuri revolves around the physics of biological, soft and active matter. A brief outline of the research performed in the group during the last one year is given below:

(i) Chromosomal organization in bacteria:

In this project our aim has been to understand the physical forces and mechanisms behind organization and dynamics of chromosome in bacteria, arguably the simplest form of living organisms. In the theoretical front, we follow a two- pronged approach. Distinguishing the two building blocks of a chromosome, the DNA filament and associated proteins, we studied the formation of local looped structure [*J. Phys. Condens. Matter* 31, 354001



(2019)], the first coarse-grained level of chromatin organization. In the other lever, we proposed a side-loop associated polymer model, *the feather-boa model* of chromosome, which we utilize to unravel the how the cellular confinement and cytoskeletal molecular crowders determine the

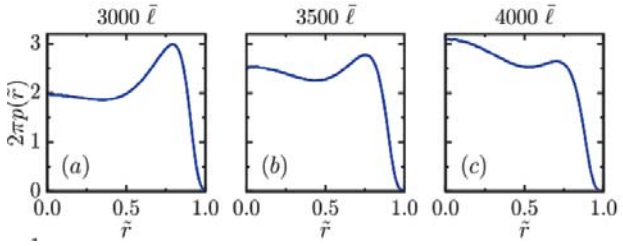
higher-level shape, size, positioning and dynamics of chromosome. Our theory describes the experimental observations on chromosomes in growing E.coli cells, satisfactorily, and has been published in the prestigious biology journal, *Current Biology* 29, 2131-2144 (2019). Our work resolved a fifty- year old problem as to how E.coli achieves precise segregation of chromosomes after replication, in the absence of any dedicated cellular machinery. The protein production around chromosomes provides physical repulsion, that moreover explains helicoid organization of the bacterial nucleoid and ribosomes around it [*EPL (Europhysics Lett.)* 128, 68003 (2019), *Soft Matter* 15, 2677–2687 (2019).].

Two of my Ph.D. students, Pinaki Swain (who has recently completed his PhD from IIT-Hyderabad and started postdoctoral research in Canada), and Amit Kumar of IOP have been involved in this project. Last year, Chitrak Karan, a new PhD student at IOP, has joined the effort.

(ii) Active matter:

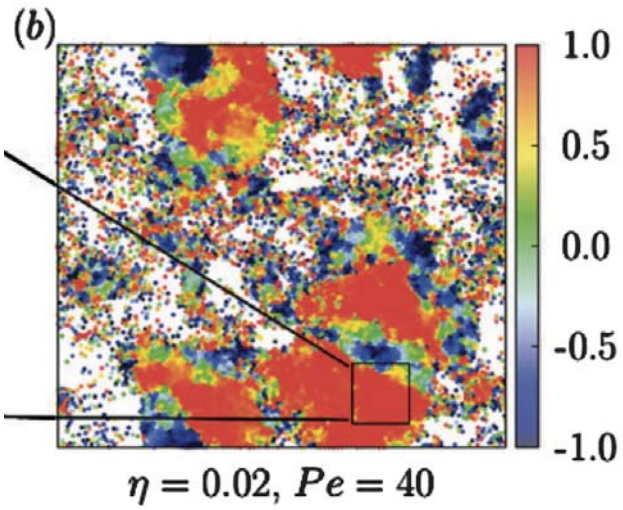
The second main area of my research involves understanding the properties of active matter. We study non-equilibrium statistical mechanics of individual (a) active Brownian particles (ABP), (b) phase transition in active colloids, (c) contractile active matter, and (d) cytoskeletal semiflexible filaments being actively driven by motor proteins (MP).

(a) Active Brownian Particles: 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 [*Soft Matter* (2020). doi:10.1039/D0SM00367K]. The displacement distribution of ABP shows a transition from the Gaussian to the bimodal distributions typical of worm- like- chain model of polymers.

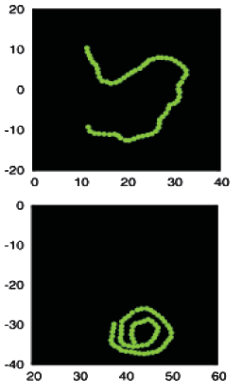
(b) Active colloids: Using extensive numerical simulations and statistical kinetic theory we determined the phase diagram of active polar particles undergoing density-mediated slowdown and nematic alignment at collision. This led to a re-entrant nematic-



isotropic- nematic first order phase transition, characterized by phae-coexistence, with increasing Peclet number [*Soft Matter* 15, 8483–8495 (2019)]. This work has been done along with a postdoctoral fellow working in our group, Dr. Biplab Bhattacherjee. Along with Debankur Das of TCIS-TIFR, Hyderabad and Biplab, we are studying the non-affine fluctuations in active solids, particularly focusing on the impact of confinement [paper in preparation].

(c) Contractile active matter: Using the paradigm of active hydrodynamics, along with my PhD student Amir Shee, we have been studying the pattern formation and dynamics of contractile active matter, similar to the actin-myosin cortex in living cells, to identify the impact of stress dependent turnover of contractility. We found an inhomogeneous pattern formation and pulsatory propagation. In a related project, Amir is studying the impact of such contractile material on the dynamics of a semiflexible polymer, to model microtubules driven by actomyosin. Further, Debankur Das of TCIS-TIFR, Hyderabad is studying the impact of contractile elements on solid membrane [papers in preparation].

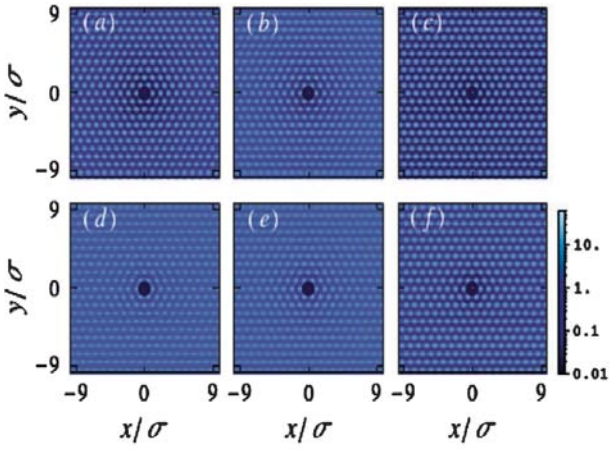
(d) Semi flexible polymers driven by MP assay: Along with Amir Shee of IOP, and in collaboration with the group of Dr. Abhishek Chaudhuri of IISER-Mohali, we have been studying the morphological transitions, size and dynamics of semi flexible cytoskeletal filaments in a gliding assay setup, using explicit modeling of motor proteins (MP). We found a series of dynamical crossovers that we could explain in terms of inertial times scale, speed fluctuations and orientational fluctuations [*Phys. Rev. E* 99, 042405 (2019)]. Our recent work shows a remarkable non-equilibrium, first order, re-entrant phase transition from open chain to torus to open chain, with increasing rate of MP extension [paper in preparation].



(D. Chaudhuri)

(iii) **Phase transitions in colloidal dispersion:**

The melting- transition of two- dimensional solids has attracted tremendous attention over the last four decades. Despite Mermin-Wagner theorem discarding long ranged order in two dimension, the Kosterlitz- Thouless- Halperin-Nelson- Young (KTHNY) theory predicted that a quasi- long ranged ordered solid may undergo a two- step continuous melting from solid to hexatic to fluid phase. However, experiments and numerical simulations led to inconclusive results, e.g., existence of Maxwell loops that characterize



a first order transition, appeared together with signatures of KTHNY transition. Along with the group of my collaborator, Dr. Dipanjan Chakraborty, we have been studying melting transitions in sterically- stabilized colloids using the Weeks-Chandler-Anderson (WCA) model, with change in density, and due to a flashing ratchet drive. Our recent wok shows two- step equilibrium melting, a continuous melting of solid to smectic, followed by a first order melting of smectic to fluid. In the presence of flashing ratchets, WCA particles show a remarkable structure- dynamics relation. At intermediate frequencies the colloidal dispersion carries the highest current by melting the solid into a hexatic phase. *[Soft Matter 16, 2552–2564 (2020).].*

(D. Chaudhuri)

PUBLICATIONS

3.1. Papers Published in Refereed Journals

1. ***Formation of topological vortices during superfluid transition in a rotating vessel,***

   Shreyansh S. Dave, Ajit M. Srivastava, Euro Phys. Lett. 126, 31001 (2019).

2. ***Synthesis and characterization of aligned ZnO nanorods for visible light photocatalysis,***

   P. Dash, A. Manna, N.C. Mishra, Shikha Varma, Physica E: Low-dimensional Systems and Nanostructures 107 (2019) 38.

3. ***Dynamics of surface evolution of rutile TiO2(110) after ion irradiation,***

   Ashis K. Manna, Vanaraj Solanki, D. Kanjilal, Shikha Varma, Radiation Effects and Defects in Solids 3-4 (2019) 174.

4. ***Impact of Nitrogen Induced Defect Dynamics on UV Response of Diamond Photodetectors*** *Sarthak Mohapatra, P. K. Sahu, S. Rath, Pratap K. Sahoo, Shikha Varma and N. V. L. Narasimha Murty, Superlattices and Microstructures 142 (2020) 106504.*

5. ***Field-independent features in the magnetization and specific heat of $Sm_3Co_4Ge_{13}$***

   Harikrishnan Nair, Ramesh Kumar R, Baidyanath Sahu, Sindisiwe Xhakaza, Pramita Mishra, Debkanta Samal, Sarit Ghosh, Biju Raja Sekhar, Andre Strydom. Crystals 9, 322 (2019.

6. ***Defects Engineered MoO_2 Nanostructures as an Efficient Electrocatalyst for OxygenEvolution Reaction,***

   P Guha, B Mohanty, R Thapa, RM Kadam, PV Satyam, BK Jena, ACS Applied Energy Materials (2020) (accepted – online)

7. ***Tuning the structural, optical, local work function and field emission properties ofmolybdenum oxide thin films with oxygen partial pressures***

   P Maiti, R Singh, B Sundaravel, A. Mitra, PV Satyam

   Journal of Applied Physics 127 (2020), 025301

8. ***Growth of Molybdenum Trioxide Nanoribbons on Oriented Ag and Au Nanostructures: A Scanning Electron Microscopy (SEM) Study***

   P. Maiti, A. Mitra, R. R. Juluri, A. Rath, and P. V. Satyam

   Microscopy and Microanalysis 25 (2019) 1449 – 1456

9. ***Facile synthesized novel hybrid graphene oxide/cobalt ferrite magnetic nanoparticles based surface coating material inhibit bacterial secretion pathway for antibacterial effect***

   T Arun, Suresh K Verma, Pritam Kumar Panda, R Justin Joseyphus, Ealisha Jha, Ali Akbari-Fakhrabadi, Pranesh Sengupta, DK Ray, VS Benitha, K Jeyasubramanyan, P V Satyam.Materials Science and Engineering C 104 (2019) 109932

10. ***Demonstration of tunable Ag morphology from nanocolumns to discrete nanoislands usingnovel angle constrained glancing angle EB evaporation technique***

    SM Haque, R De, A Mitra, JS Misal, C Prathap, PV Satyam, KD Rao

    Surface and Coatings Technology 375 (2019) 363.

11. ***Microscopy and Spectroscopy Study of Nanostructural Phase Transformation from â-MoO3to Mo under UHV–MBE Conditions***

    P. Maiti, P. Guha, H. Hussain, R. Singh, C. Nicklin, P.V. Satyam

    Surface Science 682 (2019) 64 – 74

12. ***Confinement-Induced Growth of Gold Nanocrystals in Hybrid Hierarchical Polymer Nanowire***

    G Manna, MK Sanyal, A Sarma, P Guha, PV Satyam

    The Journal of Physical Chemistry C 123 (2019), 20649-20654

13. ***Papers Published in Refereed Journals: A note on Quantum Fields in Conformally flat Space-times,***

    S. Mishra, S. Mukherji and Y. Srivastava, Modern Physics Letters A,

    Vol. 33, No. 1 (2019) 1950348

14. ***Effect of density and nucleon-nucleon potential on thefusioncross section within the relativistic mean field formalism,***

    M. Bhuyan, Raj Kumar, Shilpa Rana, D. Jain, S. K. Patra, and B.

    V. Carlson, Phys. Rev. C101 (2020) 044603.

15. ***Clustering effects in the exit channels of 13,12C +12Creactions within the collective clusterization mechanism of thedynamical cluster decay model,***

    Rupinder Kaur, Sarbjeet Kaur,BirBikram Singh, B. S. Sandhu, and S. K. Patra, Phys. Rev. C101 (2020) 034614.

16. ***Density dependence of symmetry energy in deformed 162Sm nucleus,***

    K. C. Naik, Manpreet Kaur, Ankit Kumar and S. K. Patra,

    Int. J. Mod. Phys. E28 (2019) 1950100.

17. ***Investigation of proton emission using deformed relativistic mean field densities,***

    T. Sahoo, Manpreet Kaur, R. N. Panda,

    Piyush R. Das and S. K. Patra, Int. J. Mod. Phys. E28 (2019) 1950095.

18. ***Neck configuration of Cm and Cf nuclei in the fission state within the relativistic mean field formalism, M. Bhuyan, B. V. Carlson,***

S. K. Patra, and Raj K. Gupta, Phys. Rev. C100 (2019)054312.

19. ***Effects of phi-meson on the EOS, maximum masses and radii of hyperon stars,***

S. K. Biswal, S. K. Patra and Shan-Gui

Zhou, The Astrophysical Journal 882 (2019) 67.

20. ***Effective surface properties of light, heavy, and superheavy nuclei,***

Abdul Quddus, M. Bhuyan and S. K. Patra, J. Phys.

G47 (2020) 045105.

21. ***Investigation of clustering effects and fragmentation in light mass nuclear systems formed in heavy ion reactions,***

Manpreet Kaur, Bir Bikram Singh and S K Patra, Indian Journal of Pure &

Applied Physics 57 (2019) 584.

22. ***Effective surface properties of Sn isotopes,***

Abdul Quddusand S K Patra, Indian Journal of Pure & Applied Physics 57 (2019) 527.

23. ***Nuclear structure and á-decay study of Og isotopes,***

R. R.Swain, B. B. Sahu, P. K. Moharana and S. K. Patra, Int. J. Mod.

Phys. E28 (2019) 1950041.

24. ***Across barrier fission analysis of At* isotopes formed in 3,4,6,8He +209Bi reactions,***

Amandep Kaur, Gurjit Kaur, S. K. Patra and Manoj K. Sharma, Nucl. Phys. A990, (2019) 94.

25. ***Correlation among the nuclear structure and effective symmetry energy of finite nuclei,***

Tabassum Naz, M. Bhuyan,Shakeb Ahmad and S. K. Patra and H. Abusara, Nucl. Phys.A987 (2019) 295.

26. ***Temperature dependent study of neutron-rich thermally fissile 244-262Th and 246-264U nuclei within E-TRMF model,***

Abdul Quddus, K. C. Naik, R. N. Panda and S. K. Patra, Nucl. Phys. A987 (2019) 222.

27. ***Temperature dependent symmetry energy of neutron-rich thermally fissile nuclei,***

Abdul Quddus, M. Bhuyan, Shakeb

Ahmad, B. V. Carlson and S. K. Patra, Phys. Rev. C99 (2019) 044314.

28. ***Experimental and simulation studies on temporal evolution of chemically etched Si surface: Tunable light trapping and cold cathode electron emission properties,***

Ranveer Singh, Safiul A. Mollick, Mahesh Saini, P. Guha, and Tapobrata Som,Journal of Applied Physics 125 (2019) 164302.

29. ***Effect of Fe ion implantation on the thermoelectric properties and electronic structures of $CoSb_3$ thin films,***

A. Masarrat, A. Bhogra, R. Meena, M. Bala, Ranveer Singh, V. Barwal, C. L. Dong, C.L. Chen, Tapobrata Som, A. Kumar, A. Niazi, K. Asokan, RSC Advances 9 (2019) 36113-36122

30. ***Thermal annealing induced strong photoluminescence enhancement in Ag-TiO_2 plasmonic nanocomposite thin films,***

J. Singh, K. Sahu, Ranveer Singh, Tapobrata Som, R.K. Kotnala, S. Mohapatra, Journal of Alloys and Compounds, 786 (2019)750-757.

31. ***Optical, Photocatalytic, and Wetting Behavior of GLAD N_2-TiO_2 Films,R. De,***

S. M. Haque, J. S. Misal, D. D. Shinde, C. Prathap, S. R. Polaki, Ranveer Singh, Tapobrata Som, and K. Divakar Rao, Phys. Status Solidi A 216 (2019) 1900021.

32. ***A Transparent Photonic Artificial Visual Cortex,***

Mohit Kumar, Tapobrata Som, and Joondong Kim, Advanced Materials 31 (2019) 1903095.

33. ***Growth of Wafer-Scale ReS_2 with Tunable Geometry toward Electron Field-Emission Application,***

M. Kumar, D. Y. Park, Ranveer Singh, M. S. Jeong, Tapobrata Som, and J. Kim ACS Appl. Mater. Interfaces 11 (2019) 35845-35852.

34. ***Tuning the Electrical and Thermoelectric Properties by N Ion Implantation in $SrTiO_3$ Thin Films and Their Conduction Mechanisms,***

A. Bhogra, A. Masarrat, R. Meena, Dilruba Hasina, M. Bala, C. L. Dong, C. L. Chen, Tapobrata Som, A. Kumar, A. Kandasami, Scientific Reports 9 (2019) 14486.

35. ***Influence of grain size on local work function and optoelectronic properties of n-ZTO/p-Si heterostructures,***

Ranveer Singh, Alapan Dutta, P. Nandi, S. K. Srivastava, and Tapobrata Som,

Applied Surface Science 493 (2019) 577-586.

36. ***Thermal annealing induced strong photoluminescence enhancement in Ag-TiO_2 plasmonic nanocomposite thin films,***

R. De, S. M. Haque, J. S. Misal, D. D. Shinde, C. Prathap, S. R. Polaki, Ranveer Singh, Tapobrata Som, and K. Divakar Rao,Journal of Alloys and Compounds 786 (2019), 750-757.

37. ***Aluminium induced crystallization of amorphous Si: Thermal annealing and ion irradiation process,***

G. Maity, R. Singhal, S. Dubey, S. Ojha, P. K. Kulriya, S. Dhar, Tapobrata Som, D. Kanjilal, and S. P. Patel, Journal of Non-Crystalline Solids 523 (2019) 119628.

38. ***Tunable optoelectronic properties of radio frequency sputter-deposited Sb_2Se_3 thin films: Role of growth angle and thickness,***

Alapan. Dutta, Ranveer Singh, S. K. Srivastava, and Tapobrata Som, Solar Energy 194 (2019) 716-723.

39. ***Tunable optoelectronic properties of radio frequency sputter-deposited Sb_2Se_3 thin films: Role of growth angle and thickness,*** *Alapan. Dutta, Ranveer Singh, S. K. Srivastava, and Tapobrata Som, Solar Energy 194 (2019) 716-723.*

40. ***Local surface conductivity mapping of single-layer graphene subject to low energy argon bombardment: Energy loss mechanism and defect induction efficiency,***

T. Basu, M. Blaskovic, S. Tripathy, F. Tian, Ranveer Singh, Tapobrata Som, S. Garaja, J. A. V. Kan, Materials Letters 256 (2019) 126638.

41. ***Crystallization of Ge in ion-irradiated amorphous-Ge/Au thin films,***

G. Maity, S. Ojha, S. Dubey, P. K. Kulriya, I. Sulania, S. Dhar, Tapobrata Som, D. Kanjilal, and S. P. Patel, CrystEngComm 22 (2020) 666-677.

42. ***An assessment on crystallization phenomena of Si in Al/a-Si thin films via thermal annealing and ion irradiation,***

G. Maity, S. Dubey, A. El-Azab, R. Singhal, S. Ojha, P.K. Kulriya, S. Dhar, Tapobrata Som, D. Kanjilal, and S. P. Patel, RSC Adv. 10 (2020) 4414-4426.

43. ***Growth angle-dependent evolution of morphology and magnetic properties of Co films on highly ordered self-organized Ge substrates,***

Safiul Alam Mollick, Ranveer. Singh, B. Satpati, S. Bhattacharyya, and Tapobrata Som, Journal of Magnetism and Magnetic Materials 498 (2020)166198.

44. ***Growth angle-dependent tunable work function and optoelectronic properties of MoO_x thin films,*** *Ranveer Singh, R. Sivakumar, S.K. Srivastava, and Tapobrata Som, Applied Surface Science 507 (2020) 144958.*

45. ***RF magnetron sputtered Ag-Cu_2O-CuO nanocomposite thin films with highly enhanced photocatalytic and catalytic performance,***

K. Sahu, A. Bisht, A. Pandey, Alapan Dutta, S. A. Khan, R. Singhal, Tapobrata Som, S. Mohapatra, Applied Surface Science, 517 (2020) 146169.

46. ***In-plane optical anisotropy and SERS detection efficiency of self-organized gold nanoparticles on silicon nanoripples: Roles of growth angle and postgrowth annealing,***

Mahesh Saini, S. Augustine, M. Ranjan, and Tapobrata Som, Applied Surface Science 512 (2020) 145703.

47. ***Measurement of(1520) production in pp collisions at 7 TeV and p-Pb collisions at 5.02 TeV***

P. K. Sahu, R. C. Baral, S. Sahoo and B. Mohanty: (2019) Paper Committee members: ID number: 3586: PWG: PWG-LF: 586: PWG: PWG-LF:

Eur. Phys. J. C (2020) 80:160

48. ***Origin and tuning of room-temperature multiferroicity in Fe-doped $BaTiO_3$***

Pratap Pal, Krishna Rudrapal, Sudipta Mahana, Satish Yadav, Tapas Paramanik, Shivam Mishra, Kiran Singh, Goutam Sheet, Dinesh Topwal, Ayan Roy Chaudhuri, and Debraj Choudhury,PRB, 101, 64409, 2020

49. ***Tetramer orbital ordering and lattice chirality in $MnTi_2O_4$***

A. Rahaman, M. Chakraborty, T. Paramanik, R. K. Maurya, S. Mahana, R. Bindu, D. Topwal, P. Mahadevan, and D. Choudhury PRB, 100, 115162, 2019

50. ***Constraints on Non-Standard Neutrino Interactions from Borexino Phase-II***

Sanjib Kumar Agarwalla et al.*

Journal of High Energy Physics 2002 (2020) 038, e-Print arXiv:1905.03512 [hep-ph]

*[*Played an important role in data analysis and in writing the draft]*

51. ***Physics Potential of ESSnSB in the presence of a Light Sterile Neutrino***

Sanjib Kumar Agarwalla, Sabya Sachi Chatterjee, Antonio Palazzo

Journal of High Energy Physics 1912 (2019) 174, e-Print arXiv:1909.13746 [hep-ph]

52. ***Dipole-Dipole interaction induced phases in hydrogen-bonded squaric acid crystal,***

Vikas Vijigiri and Saptarshi Mandal, 2020, J Phys. Condens Matter, 32, 285802

53. ***Higher Order Topological Insulator via Periodic driving,***

Arnob Kumar Ghosh, Ganesh C. Paul and Arijit Saha, Phys. Rev. B 101, 235403 (2020)

54. ***Tailoring Metal Insulator Transitions & Band Topology via Off-resonant Periodic Drivein an Interacting Triangular Lattice,***

Sayan Jana, Priyanka Mohan, Arijit Saha and Anamitra Mukherjee, Phys. Rev. B 101, 115428 (2020)

55. ***Impact of strong correlations on a band topological insulator on the Lieb lattice,***

Sayan Jana, Arijit Saha and Anamitra Mukherjee, Phys. Rev. B 100, 045420 (2019)

56. ***Jackiw-Rebbi zero modes in non-uniform topological insulator nanowire,***

Sayan Jana, Arijit Saha and Sourin Das, Phys. Rev. B 100, 085428 (2019)

57. ***Manipulation of exciton and trion quasiparticles in monolayer WS_2 via charge transfer***

A. P. S. Gaur, A. M. Rivera, S. P. Dash, S. Dey, R. S. Katiyar, and S. Sahoo, Appl. Phys. Lett. 115, 173103 (2019).

58. ***Influence of low energy Ag ion irradiation for formation of Bi_2Se_3 phase from Bi/$GeSe_2$ heterostructure thin films,***

A. Aparimita, R. Naik, S. Sahoo, C. Sripan, R. Ganesan, Appl. Phys. A 126, 203 (2020).

59. ***Influence of Li ion implantation on LO phonon broadening and bandgap opening in ZnO thin films***, *S. K. Das, G. K. Pradhan, and P. D. Bhuyan, S. K Gupta, S. Sahoo, J. Alloys. Comp. 806, 1138, 2019.*

60. ***Search for top squark pair production in a final state with two tau leptons in proton-proton collisions at sqrt(s) = 13 TeV,***

A.M. Sirunyan ... A. Nayak et al. (The CMS Collaboration), JHEP 02 (2020) 015, arXiv: 1910.12932 [hep-ex].

61. ***Measurement of the top quark pair production cross section in dilepton final states containing one tau lepton in pp collisions as sqrt(s) = 13 TeV,***

A.M. Sirunyan ... A. Nayak et al. (The CMS Collaboration), JHEP 02 (2020) 191, arXiv:1911.13204

62. ***Active Brownian particles: mapping to equilibrium polymers and exact computation of moments,***

Shee, A., Dhar, A. & Chaudhuri, D. ***Soft Matter 16, 4776 (2020).***

63. ***A structure–dynamics relationship in ratcheted colloids: resonance melting, dislocations, and defect clusters,***

Khali, S. S., Chakraborty, D. & Chaudhuri, D ***, Soft Matter*** *16, 2552–2564 (2020).*

64. ***Impact of crowders on the morphology of bacterial chromosome,***

Kumar, A., Swain, P., Mulder, B. M. & Chaudhuri, D. EPL (Europhysics Lett.) 128, 68003 (2019).

65. ***Cell Boundary Confinement Sets the Size and Position of the E. coli Chromosome,***

Wu, F., Swain P.… Chaudhuri, D., Mulder, B., Dekker, C.Current Biology 29, 21312144 (2019).

66. ***Re-entrant phase separation in nematically aligning active polar particles,****Bhattacherjee, B. & Chaudhuri, D. Soft Matter 15, 8483–8495 (2019).*

67. ***Confinement and crowding control the morphology and dynamics of a model bacterial chromosome,***

Swain, P., Mulder, B. M. & Chaudhuri, D.Soft Matter 15, 2677–2687 (2019).

68. ***Morphological and dynamical properties of semiflexible filaments driven by molecular motors,***

Gupta, N., Chaudhuri, A. & Chaudhuri, D. Phys. Rev. E 99, 042405 (2019).

69. ***Cross-linker mediated compaction and local morphologies in a model chromosome,****Kumar, A. & Chaudhuri, D. J. Phys. Condens. Matter 31, 354001 (2019).*

70. ***Mixed Valent Antimony Induced Disorder in Substituted Antiferromagnetic Mn_2SnS_4***

T. S. Dash, S. D. Kaushik, S. N. Sarangi, D Samal, S. Moun, C. S. Yadav, and S L Samal Dalton Transactions, 49, 6425 (2020).

71. ***Robust weak anti-localization due to spin-orbital entanglement in Dirac material Sr_3SnO***

H. Nakamura, D. Huang, J. Merz, E. Khalaf, P. Ostrovsky, A. Yaresko, D. Samal, and H. Takagi, Nature Communications,11, 1161 (2020).

72. ***Complex Magnetic Structure and Related Thermodynamic Properties of Mn_2SnS_4***

Tuhin Subhra Dash, Subham Naik, S. D. Kaushik, D. Samal, and S. L. Samal, Journal of magnetism and magnetic materials 497, 165991 (2020).

73. ***Unusual valance state in the antiperovskites Sr_3Sno and Sr_3PbO revealed by X-ray photoelectron spectroscopy,***

D. Huang, H. Nakamura, K. Küster, A. Yaresko, D. Samal, N. B. M. Schröter, V. N. Strocov, U. Starke, and H. Takagi, Physical Review Materials 3, 124203 (2019).

74. ***Conformal properties of soft-operators. Part II. Use of null-states,***

S.Banerjee and P.Pandey, JHEP, 2002, 067 (2020), doi: 10.1007/JHEP02 (2020) 067

75. ***Modified celestial amplitude in Einstein gravity,***

JHEP, 2003, 125 (2020),

S.Banerjee, S.Ghosh, P.Pandey and A.P.Saha,

Doi: 10.1007/JHEP03 (2020)125

76. ***Symmetries of free massless particles and soft theorems,***

S.Banerjee, Gen.Rel.Grav. 51, no. 9, 128 (2019), doi: 10.1007/s10714-019-2609-z,

77. ***BMS Symmetry of Celestial OPE'',***

S.Banerjee, S.Ghosh and R.Gonzo

JHEP 04, 130 (2020), doi: 10.1007/JHEP04 (2020)130,

78. ***Probing Doubly and Singly Charged Higgs at pp Collider HE-LHC***

Rojalin Padhan, Debottam Das, Manimala Mitra,Aruna KumarNayak. e-Print: 1909.10495 [hep-ph] Phys.Rev.D 101 (2020) 7, 075050

79. ***Probing Lepton Flavor violating decays in MSSM with Non-Holomorphic Soft Terms***

Utpal Chattopadhyay, Debottam Das, Samadrita Mukherjee, e-Print: 1911.05543 [hep-ph] JHEP 06 (2020) 015.

80. ***Minimal Model of Torsion Mediated Dark Matter***

Basabendu Barman, Tapobroto Bhanja,Debottam Das, Debaprasad Maity, e-Print:1912.09249 [hep-ph] (Phys.Rev.D 101 (2020) 7, 075017)

81. ***Doubly-charged Higgs boson at a future electron-proton collider,***

P. S. Bhupal Dev, Sarif Khan, Manimala Mitra, and Santosh Kumar Rai, Phys.Rev. D99 (2019) no.11, 115015

82. ***Sensitivity of Lepton Number Violating Meson Decays in Different Experiments,***

Eung Jin Chun, Arindam Das, Sanjoy Mandal, Manimala Mitra, and Nita Sinha, Phys.Rev. D100 (2019) no.9, 095022.

83. ***Same-sign tetralepton signature at the Large Hadron Collider and a future pp collider,***

Eung Jin Chun, Sarif Khan, Sanjoy Mandal, Manimala Mitra, and Sujay Shil, Phys.Rev. D101 (2020), 075008.

84. ***Signature of R2-tilde leptoquark at the upcoming ep collider,***

Rojalin Padhan, Sanjoy Mandal, Manimala Mitra, and Nita Sinha, Phys.Rev. D101 (2020) 075037.

85. ***Analyticity properties of scattering amplitude in theories with compactified space dimensions***

Jnanadeva Maharana Published in Nucl.Phys. B (2019) 114619

J. Maharana (INSA Senior Scientist)

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

1. ***Measurements of inclusive jet spectra in pp and central Pb-Pb collisions at 5.02 TeV;***

Phys. Rev. C 101, (2020) 034911.

2. ***Scattering studies with low-energy kaon-proton femtoscopy in proton-proton collisions at the LHC**, Phys. Rev. Lett. 124 (2020) 092301.*

3. ***Studies of J/ø production at forward rapidity in Pb-Pb collisions at 5.02 TeV,** JHEP 02 (2020) 041.*

4. ***Measurement of electrons from heavy-flavour hadron decays as a function of multiplicity in p-Pb collisions at 5.02 TeV****, JHEP02 (2020) 077.*

5. ***Measurement of prompt D0 , D+, D"+, and D+s production in p"Pb collisions at 5.02 TeV****, JHEP 2019 (2019) 92.*

6. ***Multiplicity dependence of light (anti-)nuclei production in p-Pb collisions at 5.02 TeV,*** *Phys.Lett. B800 (2020) 135043 .*

7. ***Measurement of charged jet cross section in pp collisions at 5.02 TeV****, Phys. Rev. D 100 (2019) 092004.*

8. ***Measurement of the inclusive isolated photon production cross section in pp collisions at 7 TeV****, Eur. Phys. J. C (2019) 79: 896.*

9. ***Measurement of Õ(1S) elliptic flow at forward rapidity in Pb-Pb collisions at 5.02 TeV,*** *Phys. Rev. Lett. 123 (2019) 192301.*

10. ***Study of the Λ -Λ interaction with femtoscopy correlations in pp and p-Pb collisions at the LHC,*** *Phys. Lett. B 797 (2019) 134822.*

11. ***3ΛH and 3Λ¯H¯ lifetime measurement in Pb-Pb collisions at 5.02 TeV via two-body decay,*** *Phys.Lett. B797 (2019) 134905 .*

12. ***Inclusive J/ø production at mid-rapidity in pp collisions at 5.02 TeV,*** *JHEP 10 (2019) 084 .*

13. ***Investigations of anisotropic flow using multi-particle azimuthal correlations in pp, p-Pb, Xe-Xe, and Pb-Pb collisions at the LHC****, Phys. Rev. Lett. 123, 142301 (2019).*

14. ***Coherent J/ψ photoproduction at forward rapidity in ultra-peripheral Pb-Pb collisions at =5.02 TeV****, Phys.Lett. B798 (2019) 134926.*

15. ***Measurement of jet radial profiles in Pb" Pb collisions at 2.76 TeV,*** *Phys. Lett. B 796 (2019) 204-219.*

16. ***Measurement of the production of charm jets tagged with D0 mesons in pp collisions at 7 TeV,*** *J. High Energ. Phys. (2019) 2019: 133.*

17. ***Production of muons from heavy-flavour hadron decays in pp collisions at 5.02 TeV,*** *JHEP (2019) 2019: 8.*

18. ***Multiplicity dependence of (anti-)deuteron production in pp collisions at 7 TeV****, Phys. Lett. B 794 (2019) 50-63.*

19. ***Λ^{+c} production in Pb-Pb collisions at =5.02 TeV, Phys.Lett.*** *B793 (2019) 212-223.*

20. ***Analysis of the apparent nuclear modification in peripheral Pb-Pb collisions at 5.02 TeV,****.Phys.Lett. B793 (2019) 420-432.*

21. ***Energy dependence of exclusive J/ø photoproduction off protons in ultra-peripheral p-Pb collisions at 5.02 TeV***, *Eur. Phys. J. C (2019) 79: 402.*

22. ***Measurement of D0 , D+, D"+ and D+s production in pp collisions at 5.02 TeV with ALICE,*** *Eur.Phys.J. C79 (2019) no.5, 388.*

23. ***Relative particle yield fluctuations in Pb-Pb collisions at 2.76 TeV; Eur****. Phys. J. C (2019) 79: 236.*

24. ***Charged-particle pseudorapidity density at mid-rapidity in p-Pb collisions at 8.16 TeV;*** *Eur. Phys. J. C (2019) 79: 307.*

25. ***Jet fragmentation transverse momentum measurements from di-hadron correlations in 7 TeV pp and 5.02 TeV p-Pb collisions****; J. High Energ. Phys. (2019) 2019: 169.*

STAR Collaboration Publication: J. Adam… P. K. Sahu... et al.

1. ***Charge-dependent pair correlations relative to a third particle in p+Au and d+Au collisions at RHIC****; Phys. Lett. B 798 (2019) 134975; e-Print Archives (1906.03373).*

2. ***Longitudinal double-spin asymmetry for inclusive jet and dijet production in pp collisions at sqrt(s)=510 GeV*** *;Phys. Rev. D 100 (2019) 52005; e-Print Archives (1906.02740).*

3. ***Measurement of inclusive J/psi suppression in Au+Au collisions at sqrt(sNN) = 200 GeV through the dimuon channel at STAR****; Phys. Lett. B 797 (2019) 134917; e-Print Archives (1905.13669).*

4. ***Polarization of Lambda (anti-Lambda) hyperons along the beam direction in Au+Au collisions at sqrt(sNN) = 200 GeV;*** *Phys. Rev. Lett. 123 (2019) 132301; e-Print Archives (1905.11917).*

5. ***Measurements of the transverse-momentum-dependent cross sections of J/ψ production at mid-rapidity in proton+proton collisions at 510 and 500 GeV with the STAR detector;*** *Phys. Rev. D 100 (2019) 52009; e-Print Archives (1905.06075).*

6. ***First observation of the directed flow of D0 and D0bar in Au+Au collisions at 200 GeV*** *; Phys. Rev. Lett. 123 (2019) 162301; e-Print Archives (1905.02052).*

7. ***Observation of excess J/psi yield at very low transverse momenta in Au+Au collisions at sqrt(sNN) = 200 GeV and U+U collisions at sqrt(sNN) = 193 GeV;*** *Phys. Rev. Lett. 123 (2019) 132302; e-Print Archives (1904.11658).*

8. ***Precise measurement of the mass difference and the binding energy of hypertriton and antihypertriton****; Nature Physics 16 (2020) 409.*

3.2 Paper to be Published.

1. *"**Re-visiting gravitational wave events via pulsars",** Minati Biswal, Shreyansh S. Dave,Ajit M. Srivastava, arXiv:1909.04476, under review with Phys. Rev. Lett.*

2. ***Scaling studies on 50 keV Ti+ ion irradiated TiO2 thin films,*** *Ashis K. Manna, Aloke Kanjilal, Dinakar Kanjilal and Shikha Varma.*

3. ***Non-Enzymatic Glucose Sensing and Bandgap Tailoring of Cu2O-ZnO Hybrid Nanostructures Prepared by Single Step Co-electrodeposition Technique,*** *Ashis K. Manna, Puspendu Guha, Vanaraj J. Solanki, S. K Srivastava, and Shikha Varma.*

4. ***Shape of Higgs Potential at Future Colliders****, Pankaj Agrawal, Debashis Saha,*

   Ling-Xiao Xu, Jiang-Hao Yu, and C.-P. Yuan, arXiv preprint arXiv:1907.02078. (To appear in Phys. Rev. D.)

5. ***Di-vector boson production in association with a Higgs boson at hadron colliders,*** *Pankaj Agrawal, Debashis Saha, and Ambresh Shivaji, arXiv preprint arXiv:1907.13168.*

6. ***Entanglement dependent bounds on conditional-variance uncertainty relations,***

   Shrobona Bagchi, Chandan Datta, Pankaj Agrawal, arXiv preprint arXiv:1909.11486.

7. ***Observation of Dirac like surface state bands in the Weak Topological Insulator****BiSe.H. Lohani, K. Majhi, S. C. Gonzalez, G. D. Santo, L. Petaccia, P.S. Anil Kumar and B. R. Sekhar Under revision in Phys. Rev. B.*

8. ***Band Structure of the Topological Insulator*** $Bi_{2-x}Cu_xSe_3$***.***

   K. Majhi, H. Lohani, S. C. Gonzalez, G. D. Santo, L. Petaccia, P. S. Anil Kumar and B. R. Sekhar. Under communication Phys. Rev. B.

9. ***Topological States of BiTe****,*

   H. Lohani, K. Majhi, S. C. Gonzalez, G. D. Santo, L. Petaccia, P.S. Anil Kumar and B. R. Sekhar. Manuscript

10. ***Electrodeposition of nanowires of a high copper content thiourea precursor of copper sulfide***

    Abhisakh Sarma, Ann-Christin Dippel, Olof Gutowski, Martin Etter, Milena Lippmann, Oliver Seeck, Gouranga Manna, Milan K Sanyal, Thomas F Keller, Satishkumar Kulkarni, Puspendu Guha, P V Satyam, Martin V Zimmermann

11. ***Effect of temperature-dependent binding energies upon fragmentation process at low energies****,*

    Manpreet Kaur, B. B. Singh and S. K. Patra, Phys. Rev. C (under review).

12. ***GW170817 constraints on the properties of neutron star in the presence of WIMP dark matter,***

    Abdul Quddus, Grigorios

    Panotopoulos, Bharat Kumar, Shakeb Ahmad, S. K. Patra, European Physics Journal C (under review).

13. ***Volume and surface contributions in the nuclear symmetry energy and magicity near N = 100 in rare earth nuclei,***

    Manpreet

    Kaur, Abdul Quddus, Ankit Kumar, M. Bhuyan and S. K. Patra, J. Phys. G (under review).

14. ***Constraining Bag constant for Hybrid Neutron stars, Ishfaq A. Rather,***

    A. A. Usmani, S. K. Patra and M. Imran, Int. J. Mod. Phys. E (under review).

15. ***Study of nuclear matter properties for hybrid EoS, Ishfaq A. Rather,***

    A. A. Usmani and S. K. Patra, J. Phys. G (under review).

16. ***Nuclear matter parameters for finite nuclei using relativistic mean field formalism within coherent density fluctuation model,***

    Ankit Kumar, H. C. Das, Manpreet Kaur, M. Bhuyan and S. K. Patra, arXiv:2002.02135.

17. ***Effects of Dark Matter on Nuclear and Neutron Star Matter,***

    H. C.Das, A. Kumar, Bharat Kumar, S. K. Biswal, T. Nakatsukasa, Ang Li and S. K. Patra; arXiv: 2002.00594; Monthly Notices of the Royal Astronomical Society (under review).

18. ***Effect of temperature on the volume and surface contributions in the symmetry energy of rare earth nuclei,***

    Manpreet Kaur, A. Quddus, A. Kumar, M. Bhuyan and S. K. Patra, Nucl. Phys. A (2020) (accepted).

19. ***A search for neutron magicity in the isotopic series of Z=122, 128 superheavy nuclei,*** *Tasleem Siddiqui, Abdul Quddus, Shakeb Ahmad and S. K. Patra, J. Phys. G (2020) (accepted).*

20. ***Measurement of D0-meson + hadron two-dimensional angular correlations in Au+Au collisions at sqrt(sNN)=200 GeV;***

    e-Print Archives (1911.12168)

21. ***Bulk Properties of the System Formed in Au+Au Collisions at sqrt(sNN) = 14.5 GeV;***

    Phys. Rev. C 101 (2020) 24905; e-Print Archives (1908.03585)

22. ***Measurement of away-side broadening with self-subtraction of flow in Au+Au collisions at sqrt(sNN)=200 GeV;*** *e-Print Archives (1906.09363)*

23. ***Strange hadron production in Au+Au collisions at sqrt(sNN) = 7.7, 11.5, 19.6, 27, and 39 GeV;***

    e-Print Archives (1906.03732)

24. ***Measurement of ion backflow fraction in GEM detectors;***

    Swain, P. K. Sahu, S. Sahu and A. Tripathy; (2019) submitted to Journal.

25. ***Application of Nilsson model for deformed nucleus in relativistic heavy ion collisions;***

S. K. Tripathy, M. Younus, P. K. Sahu and Z. Naik; (2019)

arXiv:1802.00639, submitted to Journal.

26. ***Hadron production in pp and p-Pb collisions: A mass dependent phenomenon:***

S. Sahoo, R. C. Baral, P. K. Sahu, M. K. Parida; (2019arXiv:1910.02947; submitted to journal.

27. ***Site-substitution in GdMnO3: effects on structural, electronic and magnetic properties***

D.Topwal, arXiv preprint arXiv:1908.02307

28. ***Improved Catalytic Activity of Pd Nanocrystals due to Facile Diffusion of Reactant Molecules across the Nanocrystal Stabilizer Layer,***

D. Topwal, Submitted to ACS Catalysis

29. ***Site-substitution in $GdMnO_3$: effects on structural, electronic and magnetic properties.***

D.Topwal , Submitted to PRB

30. ***Microstructured $CH_3NH_3PbI_3$ films for Efficient Solar Cells under Ambient Conditions***

Submitted to Thin solid films D.Topwal

31. ***Can Lorentz Invariance Violation affect the Sensitivity of Deep Underground Neutrino Experiment?***

Sanjib Kumar Agarwalla, Mehedi Masud

Submitted in European Physical Journal C (EPJC); e-Print arXiv:1912.13306 [hep-ph]

32. ***Enhancing Sensitivity to Non-Standard Neutrino Interactions at INO combining muon and hadron information***

Amina Khatun, Sabya Sachi Chatterjee, Tarak Thakore, Sanjib Kumar Agarwalla

Submitted in European Physical Journal C (EPJC); e-Print arXiv:1907.02027 [hep-ph]

33. ***Defect production and quench dynamics in three-dimensional Kitaev model ,***

Dibyendu Rana, Subhajit Sarkar, Saptarshi Mandal , arXiv 1812.09923

34. ***Interacting fermions in two dimension in simultaneous presence of disorder and magnetic field,*** *Saptarshi Mandal, Sanjay Gupta arXiv 1911.034666*

35. ***Existence of nodal line semi-metal in a generalized three dimensional Haldane model,***

Sudarshan Saha, Saptarshi Mandal , arXiv 1911.09894

36. ***Thermal conductivity of free-standing silicon nanowire using Raman spectroscopy,***
Sandhyarani Sahoo, Sameer Kumar Mallik, Mousam Charan Sahu, Anjana Joseph, Bibhudutta Rout, Gopal K. Pradhan, Satyaprakash Sahoo, arXiv:2002.11540 (2020) (communicated)

37. ***Superconductivity in Ag implanted Au thin film,***

M. Dalai, B. Bhusan Singh, S. Sethy, S. Sahoo, S. Bedanta, arXiv:1906.02091 (2019) (communicated).

38. ***Probing Heavy Dijet Resonances Using Jet Substructure at the LHC,***

A. K. Nayak, S. K. Rai, T. Samui, arXiv:1912.03511[hep-ph], , Submitted to PRD

39. ***Search for a light charged Higgs boson in the H to cs channel at13 TeV,***

A. Nayak et al. (The CMS Collaboration), CMS-PAS-HIG-18-021. (

40. ***Active Brownian particle in harmonic trap: exact computation of moments, and re-entrant,***

Chaudhuri, D. & Dhar, AarXiv:2005.14234, submitted in J. Stat. Mech.: Theor Expt.

41. ***Evidence for dimensionality driven weak antilocalization-weak localisation crossover near metal-insulator transition in $CaCu_3Ru_4O_{12}$***

Subhadip Jana, Shwetha G.Bhat, B.C.Behera, L.Patra, P.S.Anil Kumar, B.R.K.Nanda, D. Samal (arXiv:1908.11128) (under review)

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

B. C. Behera, S. N. Sarangi, D. Samal and S. K. Tripathy (under review)

43. ***Enhancement of Higgs Production through Leptoquarks at the LHC***

*Arvind Bhaskar, Debottam Das,Bibhabasu De, Subhadip Mitra,**e-Print:**2002.12571.*

3.3 Conference Proceedings

1. ***Scattering in Higher Dimensional Field Theories: Analyticity Properties and High Energy Behavior**, Published in PoS ICHEP2018 (2019) 266.*

J. Maharana (INSA Senior Scientist)

2. ***Construction of a single GEM detector using indigenous anode plate;***

A. Tripathy, S. Swain, P.K Sahu and S. Sahu; 23rd conference in the DAE-BRNS HEP series.

3. ***Measurement of Ion backflow with GEM-based detectors;***

S. Swain, P. K. Sahu, S.K Sahu, S. N. Nayak and A. Tripathy; 23rd conference in the DAE-BRNS HEP series.

4. ***Enhanced production of multi-strange hadrons in proton-proton collisions;***

Sarita Sahoo, R.C. Baral P.K. Sahu and M.K. Parida; 23rd conference in the DAE-BRNS HEP series.

5. ***Characterisation of Metal by GEM Detector using Ion Beam Facility at IOP;***

A. Tripathy , P.K Sahu , S. Swain, S. Sahu and B. Mallick; 23rd conference in the DAE-BRNS HEP series.

6. ***Convenor of the Theoretical Physics Seminar Circuit (TPSC) at Institute of Physics, Bhubaneswar***

http://newweb.bose.res.in/LinkageProgrammes/TPSC/CentersConvenors.jsp

(S.K. Agarwala)

3.4 Books

1. *Surface Science for Solar Future with Shikha- A conversation with a condensed matter physicist: in Book titled '31 Fantastic Adventures in Science' authored by Aashima Freidog and Nandita Jayaraj. (Publisher Penguin) (https://penguin.co.in/book/uncategorized/31-fantastic-adventures-in-science-women-scientists-in-india/)*

(S.Varma)

COLLOQUIA AND SEMINARS

4.1. Colloquia & Popular Talk

4.1.1. Colloquia

Sl. No	Date	Name and address of Speaker	Title
1	05.07.2019	Thomas Sharp, Executive Editor IOP Publishing, Bristol, UK	How to get your research published, from IOP Publishing
2	25.09.2019	Prof. Deshdeep Sahdev Director, Quazar Technologies, New Delhi.	Indigenous Instrumentation and computational packages fo cutting-edge research in India
3	15.11.2019	Prof G. Baskaran, IMSc Chennai	Room Temperature superconductivity from RVB theory perspective
4	06.12.2019	Prof. Mukunda P. Das Department of Theoretical Physics, RSPE, The Australian National University, Australia	Surprises, Puzzles and Ongoing Discoveries on Superconductivity Condensed Matter Sciences
5	20.01.2020	Chien-Peng Yuan Michigan State University, USA	QCD analysis of Parton Distribution Functions and Collider Phenomenology
6	21.01.2020	Professor Jogesh Chandra Pati Professor Emeritus, University of Maryland and Visiting Professor, SLAC, Stanford University	A Perspective of Unification Ideas in Particle Physics and Beyond
7	07.02.2020	Prof. Rajaram Nityananda Azim Premji University	The 2019 Nobel prize for physics
8	12.02.2020	Prof. V.M. Datar INO Cell, TIFR, Mumbai	Nobel prizes in Nuclear Physics
9	13.03.2020	Prof. Kajari Mazumdar, Tata Institute of Fundamental Research, Mumbai	First decade of LHC over, 2 more to go!

4.2. Seminars

4.2.1. Seminar of General Interest

1	21.06.2019	Prof. Amitabha Nandi, IIT Bombay	Kinetochore capture by spindle microtubules: a study in fission yeast
2	27.11.2019	Dr. Bimal P. Mahapatra Sambalpur University	A New General Approximation Scheme (NGAS) and Related Perturbation Theory for Arbitrary Coupling Strength in Quantum Theory
3	16.12.2019	Shri Gigi Joseph BARC, Mumbai	Cyber security awareness program
4	07.01.2020	Prof. Sashi Satpathy Department of Physics, University Missouri, USA	Hall Effect in Condensed Matter Physics: Basic Concepts and Current Research
5	11.02.2020	Dr. Vivek Datar, BARC INO Cell, TIFR, Mumbai	The India based Neutrino Observatory, mini-ICAL and a shallow ICAL
6	17.02.2020	Prasanta Panigrahi IISER Kolkata	'Quantum' Light
7	09.03.2020	Advocate (Ms.) Rama Sarode, Secretary- Sahyog Trust,	Understanding Gender and Equality Learning From "Me Too" movement,

4.2.2. Lecture Series

1	04.12.2019	Professor Mukunda P Das The Australian National University	Quantum Hall Effect(IQHE)
2	09.12.2019	Professor Mukunda P Das The Australian National University	Quantum Hall Effect(FQHE)
3	15.01.2020	Dr. Priyotosh Bandyopadhyay IIT, Hyderabad	Perspective of extended Higgs sectors in beyond Standard Model scenarios: Non-Supersymmetric and Supersymmetric part-1
4	16.01.2020	Dr. Priyotosh Bandyopadhyay IIT, Hyderabad	Perspective of extended Higgs sectors in beyond Standard Model scenarios: Non-Supersymmetric and Supersymmetric PART-2
5	16.01.2020	Dr. Priyotosh Bandyopadhyay IIT, Hyderabad	Perspective of extended Higgs sectors in beyond Standard Model scenarios: Non-Supersymmetric and Supersymmetric
6	17.01.2020	Dr. Priyotosh Bandyopadhyay IIT, Hyderabad	Perspective of extended Higgs sectors in beyond Standard Model scenarios: Non-Supersymmetric and Supersymmetric
7	19.02.2020	Prof. J.C Pati SLAC, Stanford University	Grand Unification
8	20.02.2020	Prof J.C.Pati SLAC, Stanford University	Grand Unification

4.2.3. Synopsis / Annual Review Talk / Defence

1	08.04.2019	Mr. Ranveer Singh IOP, Bhubaneswar	Growth and Characterization of CdTe-based Multijunction Hole- blocking Solar cell
2	15.05.2019	Ganesh C Paul IOP, BHubaneswar	RKKY exchange interaction in 8-Pmmn Borophene
3	23.05.2019	Amit Kumar IOP, Bhubaneswar	Micrsostructure formation on model chrosomes
4	23.05.2019	Vijigirivikas IOP, Bhubaneswar	Review on organic quantum pseudo-spin 1/2 crystal: squaric acid(H2SQ)
5	27.05.2019	Biswajit Das IOP, Bhubaneswar	EW NLO Corrections to W/Z + b $\bar{b}$ production at hadron collider
6	27.05.2019	Sujay Shil IOP, Bhubaneswar	Collider signature of Seesaw mechanism
7	28.05.2019	Amina Khatun	Constraining New Physics with Atmospheric

		INO	Neutrinos
8	29.05.2019	Ashis K Manna IOP, Bhubaneswar	Growth of TiO2, ZnO Nanostructured Films for Investigation of Resistive Switching, Photo-Absorbance Properties, Glucose Sensing and Structural Phase Transition
9	12.06.2019	Mahesh Saini IOP, Bhubaneswar	Nanoscale functionalization of ion-beam-induced self-organized nanostructures on silicon surfaces
10	14.06.2019	Alapan Dutta IOP, Bhubaneswar	Growth and characterization of Sb2Se3-based multijunction hole-blocking solar cell
11	17.06.2019	Rupam Mandal IOP, Bhubaneswar	Nanoscale resistive switching in Ta-doped SrTiO3
12	17.06.2019	Dilruba Hasina IOP, Bhubaneswar	Nanoscale functionalization of ion-implanted TiO2 films
13	25.06.2019	Arnob Kumar Ghosh IOP, Bhubaneswar	Higher Topological Insulators
14	25.06.2019	Aisha Khatun IOP, Bhubaneswar	Majorana in Shiba bands
15	25.06.2019	Pritam Chatterjee IOP, Bhubaneswar	Weyl Superconductor
16	26.06.2019	Partha Paul IOP, Bhubaneswar	Some aspects of holography and black hole Perturbation
17	01.07.2019	Paramita Maiti IOP, Bhubaneswar	Molecular Beam Epitaxy grown Molybdenum Oxide Nanostructures: Growth, Characterizations, and Applications
18	10.07.2019	Aatnu Maity IOP, Bhubaneswar	Mognonic contribution to thermal transport in Hollandite lattice
19	16.07.2019	Bibhabasu De IOP, Bhubaneswar	Enhancing Scalar Productions with Leptoquarks at the LHC
20	16.07.2019	Rojalin Padhan IOP, Bhubaneswar	Analysis of multi lepton signature in Type-II Seesaw Model
21	16.07.2019	Sudarshan Saha IOP, Bhubaneswar	3D Topological Insulator on Diamond Lattice

22	19.07.2019	Gupteswar Sabat IOP, Bhubaneswar	Structural and magnetic property of Spinel Vanadate CoV_2O_4 epitaxial thin film
23	22.07.2019	Debjyoti Majumdar IOP, Bhubaneswar	Rigidity of DNA near Melting
24	23.07.2019	Sayan Jana IOP, Bhubaneswar	Impact of strong correlations on a band topological insulator on the Lieb lattice
25	24.07.2019	Sumit Nandi IOP, Bhubaneswar	Quantum Information Processing Protocols and Entanglement
26	25.07.2019	Ashis K Manna IOP, Bhubaneswar	Growth of TiO2, ZnO Nanostructured Films for Investigation of Resistive Switching, Photo-Absorbance Properties, Glucose Sensing and Structural Phase Transition
27	26.07.2019	Saiyad Ashanujjaman IOP, Bhubaneswar	Type-III Seesaw: Phenomenological Implications of the Information Lost in Decoupling from High-energy to Low-energy
28	26.07.2019	Avnish IOP, Bhubaneswar	Collider Signatures of a Radiative Neutrino Mass Generation Mechanism
29	26.07.2019	Pranjal Pandey IOP, Bhubaneswar	Higher Order OPE of Yang Mills Celestial Amplitude
30	26.07.2019	Diwakar IOP, Bhubaneswar	Higgs CP measurement in H to di-tau to di-rho decay channel and HLT trigger studies
31	26.07.2019	Vinay Krishnan IOP, Bhubaneswar	Higgs CP analysis on Higgs to ditau events
32	31.07.2019	Amir Shee IOP, Bhubaneswar	Tight coupling between advection and strain rate Field dependent turnover drives pattern in active fluids
33	27.08.2019	Sudheer IOP, Bhubaneswar	Enhanced electron field emission of self-organized nanostructured ultra-thin gold films
34	16.09.2019	Biplab Bhattacharjee IOP, Bhubaneswar	Re-entrant phase separation in nematically aligning active polar particles
35	23.09.2019	Manpreet Kaur IOP, Bhubaneswar	Inputs from Relativistic mean-field theory to different approaches to study nuclear structure

36	27.09.2019	Sitender Kashyap IOP, Bhubaneswar	Application of pure spinor supersting to mass renormalization
37	18.10.2019	Pronoy Nandi IOP, Bhubaneswar	Structural and Spectroscopic Investigations of Organic-Inorganic Hybrid Lead Halide Perovskites
38	25.11.2019	Partha Paul IOP, Bhubaneswar	Some Aspects of Holography and Black Holes
39	05.12.2019	Ganesh C. Paul IOP, Bhubaneswar	Transport and magnetic exchange properties of various 2D Dirac materials and Majorana zero modes
40	18.12.2019	Priyo Shankar Pal IOP, Bhubaneswar	Studies on Work Extraction From Small Scale Systems and Fluctuation Theorems
41	10.01.2020	Arpan Das IMSc, Chennai	Manifestation of Entanglement in Quantum Foundation & Quantum Thermodynamics
42	22.01.2020	Mahesh Saini IOP, Bhubaneswar	Nanoscale Functionalization of Ion-Beam fabricated self-organized Nanostructures on silicon surfaces

4.2.4. Seminar of High Energy Physics

1	30.04.2019	Prof.Prafulla Behera IIT, Madras, chennai	Higgs boson measurements at LHC
2	29.07.2019	Dr. Debarati Roy	Discovery Prospects with jets @LHC
3	20.09.2019	JyotiSaha, Kalyani University	Unveiling a chiral fourth generation with double Higgs production in a type-II two-Higgs double model
4	30.09.2019	Narayan Rana, INFN, Italy	Precision physics for the LHC and beyond
5	29.11.2019	Dr. Sanjoy Mandal IMSc	Lepton Number violating meson decays, vacuum satbility in type-I seesaw extented models and Leptoquark search at colliders
6	09.01.2020	Dr. Anushree Ghosh (INFN, Padova)	Reconstruction @MINERvA: From traditional to machine learning techniques
7	16.01.2020	Dr. Arka Santra (Instituto de Fisica Corpuscular, Valencia, Spain)	Magnetic Monopole Search and Beyond: Recent Results and Future Plans for the MoEDAL Experiment at the LHC
8	17.01.2020	Chien-Peng Yuan Michigan State University, USA	QCD soft gluon resummation and Collider Phenomenology
9	21.01.2020	Basabendu Barman IIT Guwahati	Phenomenology of Singlet-doublet Fermionic Dark Matter
10	22.01.2020	Swagata Ghosh University of Calcutta	Phenomenology of scalar extension in the Standard Model
11	22.01.2020	Tarak Nath Maity IIT Kharagpur	Non-standard annihilation of scalar dark matter

12	23.01.2020	Rafiqul Rahman IISER, Kolkata	Probes of anomalous gauge boson self-couplings and the role of spin-1 polarizations
13	23.01.2020	Anirban Biswas, IACS	Reconciling dark matter, $R_{K^{(*)}}$ anomalies and $(g-2)_{\mu}$ in an ${L_{\mu}-L_{\tau}}$ scenario
14	29.01.2020	Dr. Disha Bhatia IACS, Kolkata	Upper limit on the mass of dark matter for self-interacting scenarios
15	29.01.2020	Dr. D. Sahoo Yonsei University, Seoul	Systematic study of massive neutrinos in B decays with and without sequential neutrino decay
16	30.01.2020	Mehedi Masud IOP, Bhubaneswar	Panorama of BSM physics at Neutrino oscillation experiments
17	30.01.2020	Dr. Kasinath Das IACS, Kolkata	Synchrotron radiation from Dark Matter annihilation in few newly discovered dwarf spheroidal galaxies
18	31.01.2020	Siddharth Dwivedi IACS	Reconstructing heavy Higgs boson masses in Leptophilic 2HDM
19	31.01.2020	Abhinash K Nayak, IMSC	Testing Electroweak-Penguin pollutions B->\pi\pi and B->\rho\rho decays
20	09.03.2020	Mritunjay Verma NAPOLI	Compactification and soft Behaviour

4.2.5. Seminar of High Energy Physics (TPSC)

1	10.12.2019	Dr. S.A. Mollick Indian Association for the Cultivation of Science, Kolkata	Tailoring the morphology and magnetic properties of Co film on ion-beam induced highly ordered Ge-substrate

4.2.6. Astrophysics Seminar

1	27.12.2019	Prof. Hiranmaya Mishra PRL, Ahmedabad	An Equation of State for Magnetized Neutron Star Matter and Tidal Deformation in Neutron Star Mergers

4.2.7. Seminar of Condensed Matter Physics

1	18.04.2019	Dr. Moumita Patra ISI Kolkata	Electron transport at interfacial quantum systems
2	20.05.2019	Dr. Kaustuv Manna, Max Planck Institute for Chemical Physics of Solids, Germany	Discovery of a topological magnet and chiral Fermions: Synthesis to Applications
3	14.06.2019	Dr. Sivabrata Sahu IIT Bhubaneswar	Theoretical model study of band gap opening and magnetism in graphene
4	08.08.2019	Dr. Debashree Chowdhury, Ben Guirion University, Beer-Sheva, Israel	The effect of time-dependent potentials on electron transport

5	09.08.2019	Nabanita Ganguly Univ. Of Calcutta	Electroweakinos in the era of the LHC
6	26.08.2019	Krishanu Saddhukhan IIT Kanpur	A novel long-lived gapless mode in tilted type II Dirac Semimetal
7	03.09.2019	Dr. Surajit Sarkar IISER Bhopal	Dynamics of magnetic impurity in the environment of Dirac systems
8	10.09.2019	Dr. Aditya N. Roy Choudhury S. N. Bose National Centre for Basic Sciences, Kolkata	Superconductor Vortex Dynamics in Weak Pinning Systems
9	*14.10.2019*	Dr. Suraka Bhattacharjee SN Bose Centre, Kolkata, India	TBD
10	13.11.2019	Dr. Sourav Kuila NIT Rourkela	Investigation of Magnetoelectric Effect and Magnetoresistance in CoFe2O4/BiFeO3 Core-ShellNanoparticles
11	06.01.2020	Dr. Sk Firoz Islam Aalto University, Finland	Light induced interfacial chiral modes in a threefold topological semimetal
12	07.01.2020	Mandeep Kumar Hooda IIT, Mandi	The electronic transport studies of topological phases, superconductivity, charge density waves, metal – insulator transitions etc. in transitionmetal tellurides: $CuxPdTe_2$ (x =0, 0.04), $ZrTe_3$, and Zr
13	09.01.2020	Dr. Arun Dadwal NCL Pune	Thermal conductivity studies on magnetite nanofluids
14	09.01.2020	Dr. Surender Lal IIT Mandi	Evolution of magnetic and dielectric properties in Sr-substituted high temperature multiferroic $YBaCuFeO_5$
15	10.01.2020	Dr. Arun Sarkar	Self-assembly and charge transport in ultrathin films
16	31.01.2020	Prof. Dillip Kumar Bisoyi (NIT Rourkela)	Material characterization
17	13.02.2020	Subhrojit MOdak IMSc	Non-Hermitian systems and Perspectives
18	21.02.2020	K.G. Paulson Pondicherry University	Quantum correlations as a resource for quantum information processing
19	25.02.2020	Dr. Bhaskar Mukherjee IACS, Jadavpur, Kolkata	Collapse and revival of quantum many-body scars via Floquet engineering
20	03.03.2020	Dr. Tanay Nag, SISSA, Trieste, Italy	Floquet generation of higher order topological phases and its quenching dynamics
21	05.03.2020	Prof. Sourin Das IISER Kolkata	Topological Superconductivity and Majorana Physics via Josephson Current
22	06.03.2020	Dr. Tanmoy Pail National Taiwan University, Taiwan	Combined experimental and theoretical studies on novel materials for low temperature devices
23	13.03.2020	Atal Bihari Swain Indian Institute Technology, Madras	Fabrication of a miniscule device for multi-stimulus energy harvesting throughphoto-magneto-piezoelectric effect and its merit in wireless self-powered sensor application

4.2.8. Quantum Information Seminar

1	01.07.2019	Sagnik Chakraborty, IMSc Chennai	Aspects of Markovianity in open quantum systems and applications of weak values

4.3 LECTURES DELIVERED BY THE INSTITUTE MEMBERS

4.3.1 POPULAR TALKS	
TITLE OF TALK	**EVENT / PLACE & DATE**
"Scientific Temper"	**Prof. A. M. Srivastava:** March for Science meeting, 6thAug.2019, Bhubaneswar.
Panelist in the Panel Discussion on "The Gender Gap in Physics - WhoseProblem is it?" at the Conference "Pressing for Progress 2019: An IPANational Conference towards Gender Equity in Physics"	**Prof. A. M. Srivastava:** University of Hyderabad, Hyderabad, 19-21 Sept. 2019.
"Science research in the spirit of 3-Idiots	**Prof. A. M. Srivastava:**Talk at TIFR-Hyderabad, 23 Sept. 2019.
Talk on "Detection of gravitational waves with LIGO" given to M.Sc. Physics students (and accompanying faculty) visiting from Charotar University of Science and echnology, Gujarat	**Prof. A. M. Srivastava:** Outreach Research AwarenessProgram-2019' at IOP, 30 Nov. 2019.
On Holistic education of children	**Prof. A. M. Srivastava:** Guest of Honor talk at theInauguration ceremony of Cohen International SchoolBhubaneswar, 18th Feb. 2020.
"From elementary particles to Cosmos"	**Prof. A. M. Srivastava:**Talk given at the National ScienceDay celebration at IOP, 28th Feb. 2020.
"The Universe, elementary particles, and dark energy"	**Prof. A. M. Srivastava:**Talk given at the National ScienceDay celebration at IOP, 28th Feb. 2020.
Excitements in Nanoscience at the Institute of Minerals and Materials Technology (IMMT)	**Prof. Shikha Varma:** Guest of Honor talk at National Science Day Bhubaneswar (Feb 2020)
Fascinating Surfaces, Nanoscience, Materials and their Applications	**Prof. Shikha Varma:** at National Science Day at Institute of Physics, Bhubaneswar (Feb 2020)
Functional Materials & Soft Condensed Matter at Research	**Prof. Shikha Varma:** Charotar University of Science and Technology (CHARUSAT), Anand, Gujarat, at IOP (Dec. 2019)
DNA as a Programmable Sensor of Nanoparticles	**Prof. ShikhaVarma** at the 'Pressing for Progress 2019 : IPA National Conference towards Gender Equity in Physics' held at University of Hyderabad, Hyderabad (Sept., 2019).

4.3.2. Seminars/Talks Delivered	
TITLE OF TALK	**EVENT / PLACE & DATE**
Prof. A. M. Srivastava	
Pulsars as Webergravitational wave detectors	Physics Dept. Syracuse University, Syracuse, USA 5th April, 2019.
"Re-visiting gravitational wave events via pulsars	University of Hyderabad, 14-17 Oct. 2019.
"Probing neutron star physics with heavy-ion collisionsand via gravitational waves"	the International Workshop on "QCD in the Nonperturbative Regime", TIF Mumbai, Nov. 2019.
"Detecting gravitational waves with pulsars as Weber Detectors	Cosmology and Astroparticle physics" at WHEPP- XVI,IIT Guwahati, Dec 2019.
"Probing initial state fluctuations in heavy-ion collisions with powerspectrum of flow coefficients",	the International Workshop "QCD with Electron-Ion Collider (QEIC)" held at IIT Bombay, Mumbai, January 4-7, 2020
"Detecting gravitational waves with pulsars",	the InternationalConference on "Emerging Issues in Cosmology and Particle Physics (EICP2)"held at Physics department, Visva-Bharati University, Santiniketan,Jan. 12-14, 2020.
"Re-visiting gravitational wave events via pulsars	Virtual Institute of Astroparticle physics, France, Nov. 22, 2019.(Link: http://viavca.in2p3.fr/ajit_srivastava.html).
"CMBR Physics and Magnetohydrodynamics inrelativistic heavy-ion collisions"	the conference,"FirstIMScdiscussion meeting on extreme QCD matter" held at IMSc, Chennai, during16-18 Sept. 2019.
Prof. S. Varma	
On Resistive Switching memory, Thermal Transport and DNA Biocompatibility for Ion irradiated Metal-Oxide and Graphene films	Pacific Microscopy Conference (APMC-12) at Hyderabad International Convention Center (HICC) (Feb. 2020)

Phase Transition in Ion Irradiated TiO2 : Resistive Switching Behaviour and DNA Biocompatibility	International Conference on Nanostructuring by Ion Beams (ICNIB-2019) organized at IGCAR, Kalpakkam (Nov. 2019)
Surface Characterization using X-ray Photoelectron Spectroscopy(XPS) and Atomic Force Microscopy (AFM)	QIP program on Radiation effects in Materials and their characterization through Advanced Techniques at School of Materials science and Technology, IIT BHU (Oct 2019)
Ion irradiated materials Characterization and Applications	QIP program on Radiation effects in Materials and their characterization through Advanced Techniques, held at School of Materials science and Technology IIT BHU (Oct 2019)
Prof. P. Agrawal	
Quantum Information and Entanglement', Three hours lectures in the `DST Funded Workshop on Quantum Science and Technology'	Pachhunga UniversityCollege, Aizawl, Mizoram, from July 29 - 31, 2019.
Prof. B. R. Sekhar	
Tuning of Surface State Bands in some Topological Insulators	Invited talk at Materials Science Conclave, IISc, Bangalore
Surface State Bands in a Weak Topological Insulator	Invited talk in AESET-2019, Dresden, Germany.
Surface State Bands in a Weak Topological Insulator	Invited talk at FQM-NISER, 2019.
Prof. P. V. Satyam	
Coherently embedded Ag nanostrctures as SERS substrates and enhancement of field emission of 2D layered structures its comparison with conventional methods	July 9th 2019 around 12:00 noon at ISMANAM ConferenceInternational Symposium of Metastable, Amorphous and Nanostructured Materials Invited Talk in ICNIB 2019 @ IGCAR Kalpakkam
Endotaxial structures by Ion Implantation its comparison with conventional methods.	6 - 8 November 2019 (5th International Conference On Nano structuring By Ion Beams:ICNIB2019.

Self-assembled Nanostructures: Electron Microscopy study	12th Asia Pacific Microscopy Conference, 3 - 7 Feb 2020
Elemental Mapping Techniques: Application to Nanostructures Organizers	Plenary talk in the 2 Day Workshop: Bringing the nanoworld together (BTNT 2019) Organizers: Oxford Instruments and NISER; 05 - 06 December 2019
Prof. T. Som	
"Tunable cold cathode electron emission from Au nanoparticle-decorated self-organized Si nanofacets" on 07.06.2019 at International Conference on Electron Microscopy and Allied Analytical Techniques	(EMAAT-2019), Himachal Pradesh University, Shimla.
"Anisotropic nanoscale resistive switching property of Au-ion implanted TiOx(x<2) films" at 10th International Workshop on Nanoscale Pattern Formation on Surfaces,	University of Surrey, Guildford, Surrey, UK.
Tunable cold cathode electron emission from Au nanoparticle-decorated self-organized Si nanofacets" in International Workshop on Nanoscale Pattern Formation on Surfaces,	University of Surrey, Guildford, Surrey, UK.
"Nanoscale functionalization of ion patterned surfaces"	at 5th International Conference on Nanostructuring by Ion Beams (ICNIB-2019), IGCAR, Kalpakkam
"3rd International Conference on Solar Energy Photovoltaics (ICSEP)"	On 21.12.2019 at KIIT University, Bhubaneswar.
Prof. P. K. Sahu	
"High Density nuclear matter and application to Astrophysics"	At Government College (Autonomous), Angul on 6th September 2019.
on "High density nuclear matter and Astrophysical Compact Star"	At Physics Department of Ravenshaw University, Cuttack on 10th April 2019.
Associate Prof. S. K. Agarwalla	
India-based Neutrino Observatory: Present Status and Physics Goals	Invited lecture given at the International Conference on Synergy of Sciences (ICSS-2020), SASTRA Deemed University, Thanjavur, Tamil Nadu, India, 29th February, 2020
Massive Neutrinos: A Window for Physics Beyond the Standard Model	Invited lecture given at the Winter Astronomy School, B. M. Birla Science Centre, Hyderabad, India, 18th February, 2020
Physics Goals of ICAL	Plenary talk given at the INO Collaboration meeting TIFR, Mumbai, India, 16th November, 2019

Phenomenology of Light Sterile Neutrino Vietnam Neutrino School, ICISE, Quy Nhon,	Two lectures (1.5 hours each) during the Vietnam, 16th to 17th July, 2019
Matter Effect in Long-baseline Experiments Kashiwa, Japan, 12th April, 2019	Invited talk given at the Prospects of Neutrino Physics Workshop, Kavli IPMU, Physics Workshop, Kavli IPMU,
India-based Neutrino Observatory: Present Status and Physics Reach	Invited talk given at the Prospects of Neutrino Physics Workshop, Kavli IPMU, Kashiwa, Japan, 11th April, 2019
Dr. Dinesh Topwal	
Forum on quantum matter Title: Spectroscopy of self-assembled networks and some Dirac materials	NISER, Bhubaneswar
Title: New generation of photovoltaic material: Understanding the fundamentals	12th Asia-Pacific Microscopy Conference (APMC-2020), Hyderabad.
Dr. Arijit Saha	
"Interplay of topology and correlation in Lieb lattice"	International Conference on Condensed Matter Physics, IEM- Kolkata, 15th November (2019).
"Interplay of topology and correlation in Lieb lattice"	Young Investigator Meet in Quantum Condensed Matter Theory, SNBNCBS (Kolkata), 12th December (2019).
Signature of Jackiw-Rebbi zero modes in Topological Insulator Nanowires heterostructures	Quantum Matter Heterostructures-2020, Puri, 17th February (2020).
"Impact of Strong Correlation on Topological Band properties of different lattice systems"	TIFR Centre for Interdisciplinary Sciences, Hyderabad, 04th February (2020).
"Impact of Strong Correlation on Topological Band properties of different lattice systems"	Harish Chandra Research Institute, Prayagraj (Allahabad), 20th February (2020).
"Impact of Strong Correlation on Topological Band properties of different lattice systems"	IIT Kanpur, 24th February (2020).
Dr. Saptarshi Mandal	
Forum on Quantum Matters	NISER, BBSR, 1st May, 2019
Shankar Fest	21st July, 2019, IMSc, Chennai
Institute Seminar	IIT Madras, 2nd July, 2019
Talk	Young Investigators Meet, SNBNCBS, Kolkata, 13th Dec, 2019
Dr. Satyaprakash Sahoo	
Invited Speaker in National Conference on Light Matter Interaction	At Nanoscale (LMIN-2019), IGCAR, Kalpakkam.

Invited Speaker in International conference on Functional Materials	(ICFM-2020) IIT Kharagpur
Invited Speaker in National Workshop on Science and Technology of Low Dimensional Systems	SOA Bhubaneswar, 2020
Invited Speaker in National Workshop on Functional Materials for Emerging Technology,	Silicon Institute of Technology, 2020
Dr. A. K. Nayak	
Summary of Higgs boson measurements at LHC, mini-review Talk, SM-BSM group session,	WHEPP 2019, December 01 - 10, 2019, IIT Guwahati.
Measurement of Higgs boson coupling to top quark at CMS,	at CMS, Plenary Talk, Anomalies-2019, July 18 - 20, 2019, IIT Hyderabad
Lecture and tutorial on use of Boosted Decision Tree in HEP,	HEP Activity classes, IIT-Hyderabad, 22nd July 2019.
Basics of elementary particles, Refresher course for college teachers,	Utkal University, Bhubaneswar, 17th Nov 2019.
Dr. Debasish Chaudhuri	
Relative organization of ribosomes and nucleoid : role of active mechanisms and entropy	Conference: "Indian Statistical Physics Community Meeting", ICTS-TIFR, Bangalore 19-21 February, 2020
Chromosome organization: role of confinement and molecular crowders	Conference: "Unravelling cellular processes - models and experiments", Orange County, Coorg (under the auspices of Indian Academy of Sciences)1-5 December, 2019
Active matter: From single particle to phase transitions	Conference: CompFlu 2019 at IISER-Bhopal 5- 7 December, 2019
DNA- protein cross-links and chromosomal morphology	Seminar at TIFR-Hyderabad 9th December, 2019
Active matter: From single particle to phase transitions	Seminar at the Physics department of IISER- Mohali 22 October, 2019
Collective drive of molecular motors: emergent dynamics in biopolymers	Conference: Molecular motors, transport, and trafficking, at NBRC, New Delhi 18-20 October, 2019

Positioning and dynamics ofchromosomes in Bacteria	Seminar at ICAS-Kolkata14th August,2019
Chromosomal organization in prokaryotes	Seminar at SNBNCBS-Kolkata13th August, 2019.
Re-entrant phase separation in nomadically aligning active polar particles	Seminar at Department of Physical Science, IISERKolkata8th August, 2019
Chromosomal organization in prokaryotes	Seminar at RRI, Bengaluru19th July, 2019
Entropic organization of bacterial chromosome set by the cellular confinement and cytosolic crowding	Seminar at JNCASR, Bengaluru17th July, 2019
Tissue mechanics and collective behavior of cells	Conference: Thirsting for Theoretical Biology 6th June, 2019
E.coli chromosome: size shape and dynamics	Meeting at SERB, New Delhi 13th May, 2019
Dr. S. Banerjee	
Amplitudes and Correlators: I gave a set of two lectures titled: Amplitudes in Gravity.	Saha Theory Workshop SINP, Kolkata, 13/01/ 2020 - 17/01/2020,
I gave a set of 12 lectures on Quantum Field Theory in SERB preparatory school in high energy physics	Organized by Tezpur University from 14/10/2019 to 9/11/2019.
Dr. D. Samal	
"Thin films of anti-perovskite oxides and related 3D Dirac semi-metallic state", National Conference on Quantum Matter Heterostructures	Puri, Feb17-19, 2020.
"Quantum Matter Heterostruture and Emergent Phenomena" Work shop on Functional Materials for Emerging Technology, (FMET-2020),	SIT Bhubaneswar, February 13-15, 2020.
Designer cuprate heterostructures for realizing Interfacial high-Tc superconductivity" National Conference on Science and Technology of Functional Materials (STFM),	Sikha 'O' Anusandhan University, Bhubaneswar, December 6-7, 2019.
Tailoring the electronic properties in synthetic cuprate layers" 8th Annual Seminar on Bringing The Nanoworld Together (BTNT),	NISER, Bhubaneswar, December 5-6, 2019.

Designer thin film heterostruture of quantum materials and emergent Phenomena" National Conference on frontiers in Advanced Materials (NCFAM-2019),	"VSSUT, Burla, Odisha, July 27-28, 2019.
"Designer thin film heterostruture of quantum materials and emergent Phenomena" National conference on Advance Materials and their applications, GCEK.	Bhawani Patna, Odisha,April20-21, 2019.
Dr. M. Mitra	
Talk title 'Seesaw searches at a Lepton Collider'	Planck 2019, Spain.
Talk title ' Charged LFV Processes'	IIT Guwahati, in December.

4.4. CONFERENCE / WORKSHOP ATTENDED BY IOP MEMBERS

Name	Conference/Workshop details
Prof. A. M. Srivastava	1. International Workshop "QCD with Electron-Ion Collider (QEIC)" held at IIT Bombay, Mumbai, January 4-7, 2020 2. International Conference on "Emerging Issues in Cosmology and Particle Physics (EICP2)" held at Physics department, Visva-Bharati University, Santiniketan, Jan. 12-14, 2020
Prof. S. Varma	1.Asia Pacific Microscopy Conference (APMC-12) at Hyderabad International Convention Center (HICC) (Feb. 2020) 2.International Conference on Nano structuring by Ion Beams (ICNIB-2019) organized at IGCAR, Kalpakkam (Nov. 2019) 3. Pressing for Progress 2019: IPA National Conference towards Gender Equity in Physics held at University of Hyderabad, Hyderabad (Sept. 2019)
Prof. P. Agrawal	1. "Workshop on Quantum Computing and Quantum Technology" at Berhampur University, from Feb 8-9, 2020 2. `DSTFunded Workshop on Quantum Science and Technology' at Pachhunga UniversityCollege, Aizawl, Mizoram, from July 29 - 31, 2019
Prof. P. V. Satyam	1. ISMANAM - July 2019 organized by IIT Madras 2.12th Asia Pacific Microscopy Conference, (APMC) 03 - 07 Feb 2020 3. 5th International Conference On Nano structuring By Ion Beams (ICNIB 2019) during 6th to 8th November 2019
Prof. T. Som	1.International Conference on Electron Microscopy and Allied Analytical Techniques (EMAAT-2019), Himachal Pradesh University, Shimla 2.10th International Workshop on Nanoscale Pattern Formation on Surfaces, University of Surrey, Guildford, Surrey, UK 3.5th International Conference on Nanostructuring by Ion Beams (ICNIB-2019), IGCAR, Kalpakkam 4.3rd International Conference on Solar Energy Photovoltaics (ICSEP), KIIT University, Bhubaneswar in December 2019
Associate Prof. S. K. Agarwalla	1. International Conference on Synergy of Sciences (ICSS - 2020), SASTRA Deemed University, Thanjavur, Tamil Nadu, India, 27th to 29th February, 2020

	2.India-based Neutrino Observatory (INO) Collaboration meeting, TIFR, Mumbai,India, 16th to 17th November, 2019 3.Prospects of Neutrino Physics Workshop, Kavli IPMU, Kashiwa, Japan, 8th to 12th April, 2019.
Dr. Dinesh Topwal	1. Forum on quantum matter, NISER, Bhubaneswar 2. International conference on advanced materials and processing for defence applications. ADMAT-2019, Hyderabad 3.12th Asia-Pacific Microscopy Conference (APMC-2020), Hyderabad 4. National conference on Quantum Matter Heterostructure (QMH) 2020, Puri
Dr. Arijit Saha	1. "International Conference on Condensed Matter Physics", IEM-Kolkata, 14-16 November, (2019) 2. "Young Investigator Meet in Quantum Condensed Matter Theory", SNBNCBS (Kolkata), 11-13 December (2019) 3. "Quantum Matter Heterostructures-2020",Puri, 17-19 February (2020)
Dr. Saptarshi Mandal	1. Forum on Quantum Matters, NISER, BBSR, 1st May, 2019 2. Gave talk in Young Investigators Meet, SNBNCBS, Kolkata, 13th Dec, 2019
Dr. Satya Prakash Sahoo	1. National Conference on Light Matter Interaction at Nanoscale (LMIN-2019), IGCAR, Kalpakkam 2.International conference on Functional Materials (ICFM-2020) IIT Kharagpur 3.National Workshop on Science and Technology of Low Dimensional Systems,SOA Bhubaneswar 4.National Workshop on Functional Materials for Emerging Technology, Silicon Institute of Technology
Dr. Aruna K Nayak	1. XVI workshop on High Energy Physics and Phenomenology, WHEPP 2019, December 01 - 10, 2019, IIT-Guwahati. Chaired one parallel session in SM-BSM group on "Review of experimental results" 2.Anomalies-2019 (Indo-US workshop), July 18 - 20, 2019, IIT Hyderabad 3.India-CMS collaboration meeting, 22-24 August 2019, Delhi University 4.India-CMS collaboration meeting, 24-25 January 2020, Panjab University

Dr. Debasish Chaudhuri	1. "Indian Statistical Physics Community Meeting", ICTS-TIFR, Bangalore 19-21 February, 2020 2. "Unravelling cellular processes - models and experiments", Orange County, Coorg (under the auspices of Indian Academy of Sciences)1-5 December, 2019 3. Conference: CompFlu 2019 at IISER-Bhopal, 5- 7 December, 2019 4. Molecular motors, transport, and trafficking, at NBRC, New Delhi18-20 October, 2019 5. Thirsting for Theoretical Biology6th June, 2019 6. Meeting at SERB, New Delhi 13th May, 2019
Dr. S. Banerjee	1.5th Indian - Israeli Meeting on String Theory: Nazareth, Israel, 17/02/2019 - 21/02/2019. 2. Gravity at different length scales: IACS Kolkata, 25/02/2019 - 27/02/2019. 3. String Theory Seminar: CHEP, IISc Bengaluru, 16/06/2019 - 21/06/2019.
Dr. D. Samal	1. National Conference on Quantum Matter Heterostructures, Puri, Feb17-19, 2020 2. Work shop on Functional Materials for Emerging Technology, (FMET-2020), SIT Bhubaneswar, February 13-15, 2020 3. National Conference on Science and Technology of Functional Materials (STFM), Sikha 'O' Anusandhan University, Bhubaneswar, December 6-7, 2019 4. 8th Annual Seminar on Bringing The Nano world Together (BTNT), NISER, Bhubaneswar, December 5-6, 2019 5. National Conference on frontiers in Advanced Materials (NCFAM-2019), VSSUT, Burla, Odisha, July 27-28, 2019 6. National conference on Advance Materials and their applications, GCEK, Bhawani Patna, Odisha, April 20-21, 2019
Dr. Manimala Mitra	1. Planck 2019 (June 3rd to 7th, 2019) - Granada, Spain 2. Anomalies2019 in IIT Hyderabad during July 18-20th 3. WHEPP-XVI at IIT Guwahati during December 01-10

4.5. AWARDS / HONOURS AND RECOGNITIONS

Prof. S. Varma

- Editorial Board member of the International Journal 'Journal of Physics: Condensed Matter' (IOP publications, London, UK)
- Review Editorial Board member of International Journal Frontier

Prof. P.V Satyam

- NALCO Projects – one as PI and another as Co-PI with IMMT
- Guest Editor: Microscopy and Microanalysis (regular journal belonging to Cambridge University Press, UK)
- Promotion belonging to CSIR Institutes and University Grants Commission
- Elected as Executive Member of CAPSM (an international body of IFSM – UN recognized member of scientific council)

Prof. T. Som

- Member, Accelerator Users' Committee, Inter-University Accelerator Centre, New Delhi.
- Member, International Committee on International Workshop on Nanoscale Pattern Formation at Surfaces.
- Member, DST Review Committee on Solar PV Hub at IIEST Shibpur.
- Member, Board of Studies in Physics, College of Engineering and Technology, Bhubaneswar.

Associate Prof. Sanjib Kumar Agarwalla

- B.M. Birla Science Prize in Physics for the year 2018

  (Sole winner of this award in 2018, announced on 10th January, 2020)
- Young Scientist Research Grant for three years (2018 to 2021) from INSA
- Member of the DAE Vision Scheme - 7 (Mega Science) Sub-committee

  (Helping Project Appraisal Committee constituted by the Secretary, DAE)

Dr. Saptarshi Mandal

- Awarded ICTP Associates, 2020-2015

Dr. Aruna Nayak

- Convener of Jets and missing energy Trigger group, Sep 2016 – Aug 2019.

- One of the three conveners to organize regular Friday India-CMS physics talks, Sep 2017-Continuing.

Dr. D. Chaudhuri

- Dr. Debasish Chaudhuri have been re-elected as an Associate of the International Center for Theoretical Studies (ICTS) – TIFR, Bangalore for the period of January, 2020 to Deecember, 2022.

Dr. Debkanta Samal

- As the head of Max Planck Partner Group at IoP, I received an extension of the Max Planck Partner Group for next two years 2020-2022.
- SERB Project entitled "Designer thin film heterostruture of quantum materials" for the period 2020-2023 is recommended for funding the PI.

Dr. Manimala Mitra

- Indian PI of the Indo-French Project funded by Indo-French Centre for the Promotion of Advanced Research (IFCPAR/ CEFIPRA), project proposal approved in 2020.

Dr. Kirtiman Ghosh

- Appointed as Visiting Faculty, IISER BerhampurJanuary 2020.
- Project titled "Exploring Radiative Neutrino Mass Models through Dark Matter and Collider Experiments." is funded by SERB Core Research Grant (CRG/2019/006831).

CONFERENCES AND OTHER EVENTS

5.1. FOUNDATION DAY

Institute of Physics, Bhubaneswar celebrated its 45th Foundation Day in its premises on 4th September 2019.Professor Ashok Kumar Das, Eminent Physicist, BARC, Mumbai, Former Vice-Chancellor, Utkal University, and Vice-Chairperson, State Higher Education Council, Odisha graced the occasion as Chief Guest. The session was chaired by Prof. Sudhakar Panda, Director, Institute of Physics, Bhubaneswar in the presence of Prof. B. R. Sekhar, Chairman & Dr. B. Mohanty, Convener of the Foundation Day Celebration Committee at the Institute's Auditorium. The meeting ended with a vote of thanks by Sri Rushi Kumar Rath, Register, Institute of Physics, Bhubaneswarfollowed by a Cultural program. Professor Das also delivered a Foundation Day talk on "**Physics and Human Society; Looking at a new equation**" meant for students and researchers from all branches of Physics. The talk was focused on howPhysics and Human society has always been evolving in a symbiotic manner. A brief abstract of his talk is given below:

Every technological era has been preceded by an important discovery in physics; starting from thermodynamics to steam engine; electromagnetics to power systems, semiconductors to VLSI or quantum mechanics to lasers, etc. The massive developments in Biosciences, chemistry, or information technologies owe their origins to advancements in Physics. The statement physics for human society is therefore a well-established concept though it is being questioned regarding its ground level efficacy in recent years. A more interesting concept that interfaces with life sciences, sociology, and anthropology is what is being commonly called as Physics of Human Society. Simply stated, it would formulate theories for human collectives leading to understanding, anticipating, and forecasting future societal trends and human behavioural responses, and their associated uncertainty1; or address societal challenges in which globally networked risks play a role. It is proposed to

(Registrar giving the vote of thanks at the end of the Foundation Day)

outlines existing thoughts in these two aspects of Physics i.e. for and of human society.

In the end, a cultural program was also organized by the IOP staff members in the form of a play entitled "**Akuha Katha**". Dr. B. Mohanty, Convener extended his thanks to the IOP Community, Media Persons, and especially the Organizing Committee.

(Cultural Programme of 45th Foundation Day of IOP)

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ଇନଷ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସର ୪୫ତମ ପ୍ରତିଷ୍ଠା ଦିବସ

ପଦାର୍ଥ ବିଜ୍ଞାନ ଗବେଷଣାରେ ବଡ଼ ଭାଇ ହେଉ ଆଇଓପି

ରାଜ୍ୟ ବିଶ୍ୱବିଦ୍ୟାଳୟଗୁଡିକ ସହ ମିଳିତ ଗବେଷଣା କରୁ

ପ୍ରତିଷ୍ଠା ହେଉ ପୂର୍ବାଞ୍ଚଳ ଇନଷ୍ଟ୍ରୁମେଣ୍ଟେସନ୍ ସେଣ୍ଟର୍

ଭୁବନେଶ୍ୱର,୪।୯(ନ୍ୟୁଜ): ପଦାର୍ଥ ବିଜ୍ଞାନ ଗବେଷଣା କ୍ଷେତ୍ରରେ ପଦାର୍ଥ ବିଜ୍ଞାନ ପ୍ରତିଷ୍ଠାନ (ଇନଷ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସ) ବା ଆଇଓପିର ବହୁ ଅବଦାନ ରହିଛି। ତେବେ ଏଠାରେ ଥିବା ପଦାର୍ଥ ବିଜ୍ଞାନୀଙ୍କ ଗବେଷଣା କାମରେ ଲାଗିବା ଆବଶ୍ୟକ। ବିଶେଷ କରି ରାଜ୍ୟ ବିଶ୍ୱବିଦ୍ୟାଳୟଗୁଡିକର ବଡ ଭାଇ ହେଉ ଆଇଓପି। ମିଳିତ ଭାବେ ପଦାର୍ଥ ବିଜ୍ଞାନର ଗବେଷଣା କରନ୍ତୁ। ଶିକ୍ଷାନୁଷ୍ଠାନଗୁଡିକୁ ମାର୍ଗଦର୍ଶନ କରନ୍ତୁ ବୋଲି ପ୍ରସିଦ୍ଧ ପଦାର୍ଥ ବିଜ୍ଞାନୀ ତଥା ଓଡ଼ିଶା ରାଜ୍ୟ ଉଚ୍ଚଶିକ୍ଷା ପରିଷଦର ଉପାଧ୍ୟକ୍ଷ ପ୍ରଫେସର ଅଶୋକ କୁମାର ଦାସ କହିଛନ୍ତି।

ବୁଧବାର ଇନଷ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସର ୪୫ତମ ପ୍ରତିଷ୍ଠା ଦିବସ ଅନୁଷ୍ଠିତ ହୋଇଯାଇଛି। ପ୍ରତିଷ୍ଠା ଦିବସରେ ମୁଖ୍ୟ ଅତିଥି ଭାବେ ଯୋଗ ଦେଇ ପ୍ରଫେସର ଦାସ କହିଛନ୍ତି ଯେ, ଜିଛି ଦିନ ପୂର୍ବରୁ ଇନଷ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସକୁ ନାଇଜର୍ ସହ ବିଲୟ କରିବାର ଯୋଜନା ହେଉଥିଲା। ଯାହା ଅନୁଚିତ୍। ଏହା ଦ୍ୱାରା ଇନଷ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସର

ପରିଚୟ ହଜିଯିବ। ୭୦ ଦଶକର ଏହି ଅନୁଷ୍ଠାନର ନିଜସ୍ୱ ପରିଚୟ ରହିଛି। ପଦାର୍ଥ ବିଜ୍ଞାନର ବିଭିନ୍ନ ଗବେଷଣା କ୍ଷେତ୍ରରେ ଜାତୀୟସ୍ତରରେ ଖ୍ୟାତି ଅର୍ଜନ କରିପାରିଛି। ତେବେ ଏହି ଅନୁଷ୍ଠାନର ବୈଜ୍ଞାନିକମାନେ କେବଳ ଅନୁଷ୍ଠାନ ପରିସରରେ ସୀମିତ ନ ରହି ଅନ୍ୟ ଶିକ୍ଷାନୁଷ୍ଠାନ ଓ ସାଧାରଣ ଲୋକମାନଙ୍କ ସହ ଯୋଡିବା ଆବଶ୍ୟକ। ସ୍ୱାସ୍ଥ୍ୟ, ଶିକ୍ଷା ଓ ପରିବେଶ କ୍ଷେତ୍ରରେ ଥିବା ସମସ୍ୟାର ସମାଧାନ ପାଇଁ ଆଗଭର ହେବା ଉଚିତ୍। ପାନୀୟ ଜଳ ସମସ୍ୟାର ସମାଧାନରୁ ଆରମ୍ଭ କରି ବର୍ତ୍ତ୍ୟମାନ ସମସ୍ତ କ୍ଷେତ୍ରରେ ସମାଧାନ ପାଇଁ ପଦାର୍ଥ ବିଜ୍ଞାନୀମାନେ ଆଗଭର ହେବା ଆବଶ୍ୟକ। ବିଶେଷ କରି ବର୍ତ୍ତମାନ ସମୟରେ ଦେଖା ଦେଉଥିବା ପରିବେଶ ଓ ଶକ୍ତି ସଙ୍କଟକୁ ମୁକାବିଲା କରିବା ପାଇଁ ପଦାର୍ଥ ବିଜ୍ଞାନୀମାନେ ଆଗକୁ ଆସିବା ଉଚିତ୍। ସେମାନେ ଚେଷ୍ଟା କଲେ ବହୁ ସମସ୍ୟାର ସମାଧାନ କରିପାରିବେ ବୋଲି ପ୍ରଫେସର ଦାସ ଆଶା ପ୍ରକଟ କରିଛନ୍ତି। ତେବେ ପ୍ରଥମେ ନିଆଁକୁ ଉଭାଇବା କରିଥିବା ପୁରୁଷ ତିନ୍ନା ମହିଳା ମଧ୍ୟ ଜଣେ ପଦାର୍ଥ ବିଜ୍ଞାନୀ ବୋଲି ସେ କହିଛନ୍ତି।

ଇନଷ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସରେ ପୂର୍ବାଞ୍ଚଳ ଇନଷ୍ଟ୍ରୁମେଣ୍ଟେସନ୍ ସେଣ୍ଟର୍ ପ୍ରତିଷ୍ଠା ହେଉ ବୋଲି ପ୍ରଫେସର ଦାସ ପ୍ରସ୍ତାବ ଦେଇଛନ୍ତି। ଫଳରେ ଏହି ଅନୁଷ୍ଠାନର ଗୌରବ ବହୁଗୁଣିତ ହୋଇପାରିବ ବୋଲି ସେ ଆଶା ପ୍ରକଟ କରିଛନ୍ତି। ଏହି ଅବସରରେ ସେ ମୁମ୍ବାଇରେ ଥିବା ପଣ୍ଡିମାଞ୍ଚଳ ଇନଷ୍ଟ୍ରୁମେଣ୍ଟେସନ୍ ସେଣ୍ଟରର ଉଦାହରଣ ଦେଇଛନ୍ତି। ଇନଷ୍ଟିଚ୍ୟୁଟ୍ ଅଫ୍ ଫିଜିକ୍ସର ପରିଚାଳକ ପ୍ରଫେସର ସୁଧାକର ପଣ୍ଡାଙ୍କ ଅଧ୍ୟକ୍ଷତାରେ ଅନୁଷ୍ଠିତ ଏହି ଉତ୍ସବାନୁଷ୍ଠାନ ଉତ୍ସବରେ ପ୍ରଫେସର ବି. ଆର୍ ଶେଖର ବକ୍ତବ୍ୟ ପ୍ରଦାନ କରିଥିବା ବେଳେ ଜୁବପତିତ ପ୍ରଫେସର ଆର୍ କେ ରଥ ଧନ୍ୟବାଦ ଦେଇଥିଲେ।

(Media coverage of 45th Foundation Day of IOP)

5.2. National Conference on Quantum Matter Heterostructure (QHM-2020)

"1st National Conference on Quantum Matter Heterostructure" organized by Institute of Physics (IOP), Bhubaneswarduring February 17-19, 2020.

Institute of Physics (IoP), Bhubaneswar, organized the 1st National Conference on Quantum Matter Heterostructure (QMH-2020) at Toshali Sands, Puri during February 17-19, 2020. The Inaugural Ceremony of the Symposium was held on 17th February, 2020 afternoon in the presence of Prof. S. M. Yusuf, Director, IoP, Prof. S. D. Mohanty (Michigan State University, USA), and Dr. Debakanta Samal, IoP, Convenor QMH-2020. Prof. S. M. Yusuf, Director, IoP, delivered the inaugural talk emphasizing the quantum behavior of electrons and emergent quantum phenomena in condensed matter system. The inaugural session was concluded with the vote of thanks given by Dr. S. N. Sarangi, IoP, Organizing Secretary of the conference QMH-2020.

The technical program of the conference consisting of 8 sessions was rich and varied with the major themes on understanding the emergent

(Inaugural session of 1st National Conference on Quantum Matter Heterostructure at Toshali Sands, Puri during February 17-19, 2020)

(Technical session of 1st National Conference on Quantum Matter Heterostructure at Toshali Sands, Puri during February 17-19, 2020)

electromagnetic phenomena in designer thin films/ heterostructures/ hybrids of quantum materials. The first plenary talk entitled" Quantum Behaviour of Electronic Spins" was delivered by Prof. S. M. Yusuf, Director, IoP in which he illustrated about the quantum magnetism in solids including the exotic spin liquid phase.

A total of 22 invited lecturers and about 20 poster presentations were included in the whole conference. 1st National Conference on Quantum Matter Heterostructurein India provided a forum for students and young researchers to interact with the faculty members and scientists from all over India in various fields of research activities related to thin films and heterostructures of quantum materials.

The speakers that includeS. M. Yusuf, BARC, Mumbai & Director, IoP, Bhubaneswar, P.S. Anil Kumar, Indian Institute of Science, Bangalore, Pratap Raychaudhuri, Tata Institute of Fundamental Research, S. D. Mahanti, Michigan State University, USA, Debakanta Samal, Institute of Physics, Bhubaneswar, Karthik V. Raman, TIFR, Hyderabad, ArijitSaha, Institute of Physics, Bhubaneswar, Subhankar Bedanta, NISER, Bhubaneswar, Pranaba Kishor Muduli, IIT, Delhi, Ashis Kumar Nandy, NISER, Bhubaneswar, Mumbai, Pratap Kumar Sahoo, NISER, Bhubaneswar, Jyoti Ranjan Mohanty, IIT, Hyderabad, Zakir Hossain, Indian Institute Technology, Kanpur, Suvankar Chakraverty, Institute of Nano Science and Technology, Mohali, Punjab, Bhaskar Chandra Behera, University of Berhampur, Berhampur, Ranjit Kumar Nanda B, IIT, Madras, Subhadip Jana, Institute of Physics, Bhubaneswar, Vivek Kumar Malik, IIT Roorkee, Nirmal Ganguli, IISER, Bhopal, Chanchal Sow, IIT-Kanpur, Abhijit Kumar, IIT, Bhubaneswar, Vivek Kumar, IISER, Bhopal enlightenedthe audience with their excellent talks on Quantum Behaviour of Electronic Spins, Magnetic proximity effect study at the surface of a topological insulator, Signature of Jackiw-Rebbi zero modes in Topological Insulator Nanowires Hetero structure, Inverse spin Hall effect in systems with heavy metals, topological insulators and antiferromagnets, Dynamics of a single skyrmion in a nanodisk: Auto-oscillations and thermal decay, Room temperature skyrmion in magnetic multilayers, Observation of Hexatic Vortex Fluid in a Thin Super Conducting Film, Exploring nanoscale magnetic heterostructures with microscopy and modeling, Interface Induced Phenomena in

(Technical session and poster session of 1st National Conference on Quantum Matter Heterostructure at Toshali Sands, Puri during February 17-19, 2020).

Perovskite Oxide Thin Films: Tunable Spin Orbit Interaction and Resistive Switching using Light and Gate Voltage, Emergent phenomena at the conducting interface of insulating oxides with strong spin-orbit coupling, Tailoring magnetism in epitaxial spinel vanadate (CoV_2O_4) thin film, Synthesizing metals out of Insulators and Insulators out of Metals in Oxide Heterostructures, Carrier-mediated inverted hysteresis in FM/FM heterostructures, Dimensionality Driven Localization Crossover Near Metal-Insulator Transition in $CaCu_3Ru_4O_{12}$, Physics and technology with quantum materials, Competing Orders in oxidehetero structures, Rashba effect and proximity-driven spintronics in 2-dimension, Physics of a transition metal di-chalcogenide (X)-TaX_2, from bulk to monolayer, Tuning the "mottness" with DC Current, Magnetism and Rashbha Effects at Interfaces of $KTaO_3$ | $BaMnO_3$. There was also a poster session during February 18, 2020. Students and faculty members from various institutions presented their research work through poster presentation and a had fruitful discussion.

Besides technical and poster sessions, a discussion meeting on the future perspective of Quantum Matter Hetero structure research in India was held during February 18, 2020. All the dignitaries from various institutions welcomed the idea of Dr. Debakanat Samal to organise such thematic conference every year under the title of "Quantum Matter Heterostructure". In the concluding session of the conference, Dr. Debakanta Samal and Prof. S. D. Mohanty thanked all the speakers and participants for their active participation and looked forward to the best use of this forum for scientific progress and collaboration on Quantum Matter Heterostructure research.

(Group Photograph 1st National Conference on Quantum Matter Heterostructure at Toshali Sands, Puri during February 17-19, 2020)

OTHER ACTIVITIES

6.1 Outreach Programme

6.1.1 National Science Day Celebration-2020

The "National Science Day Celebration-2020" was conducted successfully on 28th February, 2020 in the Institute. Prof. S. M. Yusuf, Director, IOP, Prof. Ajit Mohan Srivastava, Prof. Shikha Varma, Institute of Physics and Dr. Mrutyunjaya Mohapatra, Director General of Meteorology, Indian Meteorological Department, New Delhi were the speakers of the programme. About 250 students and 50 teachers from Jawahar Navodaya Vidyalayas across Odisha participated in this programme. On 27.02.2020 evening sky watch programme through telescope were arranged at the Institute. About 250 participants attended this programme. The event was inaugurated by Prof. S. M. Yusuf, Director, Dr. Debakanta Samal, Convener, National Science Day Organizing Committee and Sri R. K. Rath, Registrar with the lighting of the ceremonial lamp. This was followed by welcome address delivered by Dr. Samal, Convener of the program highlighting the significance of celebrating the Science Day in remembrance of Sir Chandrashekhara Venkata Raman for receiving the noble prize for discovery of Raman Effect. Sri R. K. Rath, Registrar proposed the vote of thanks. Prof. S. M. Yusuf, Director of the Institute delivered a talk on "Neutrons in Material Science and Technology" followed to more scientific talks by faculty members of the Institute. Prof. Shikha Varma, IOP delivered on "Fascinating

(Chief Guest Prof. S. M. Yusuf, Director (Right) and Dr. Debakanta Samal, Convener (Left) during the inaugural function of NSD-2020)

Surfaces, Nanosicences, Materials and their Applications " while Prof. Ajit Mohan Srivastava, IOP delivered a talk on "From Elementary Particles to Cosmos "to the gathering. Dr. Mrutyunjaya Mohaptra, Director General of Meteorology, Indian Meteorological Department, and New Delhi was Chief Guest-cum- Speaker of the programme. He delivered an invited talk on "Cyclone Warning: A Science for the Society". All Student and Teacher participants visited the different laboratories of the Institute. The students from 25 Nos. JNVs across Odisha were participated in the National Science Day Celebration-2020. Every School had presented one Science Model during the exhibition function. Best three models were awarded with a token of appreciation with certificate of merit.

(Participants, Guests and Delegates during the Valedictory Session of the function)

6.1.2 Sky watch Programme

1. Prof. A. M. Srivastava organized observational session (with a telescope using projection system), along with SCAAA members, for the solar eclipse on 26th Dec.2019, at IOP for IOP members and general public.
2. Conducted night sky view on 27th Feb. 2020 with 2 Telescopes and 2 binoculars (showing Moon craters, Venus, Uranus, Orion nebula) for about 200 students and teachers visiting from Jawahar Navodaya Vidyalayas across Odisha for National Science day celebration (held at IOP on 28th Feb.), & for members of IOP. Prof. S. M. Yusuf, Director IOP interacted with the students & appreciated their enthusium.

6.1.3 Prof. Shikha Varma Arranged Outreach Research Awareness Program for the M.Sc. Students from CHARUSAT, Gujarat, held during 30 Nov. to 4 Dec. 2019 :

The purpose of the program was to have intense interaction between the students and scientists of IOP and comprehensive exposure to experimental facilities at IOP in order to inspire the students for Physics Research. For this program 10 M.Sc. students and some Faculty members of KRADLE and PDPIAS had visited Institute of Physics, Bhubaneswar, during 30th November to 4th December 2019. Under this awareness program many IOP faculty members gave lectures, on their research program, to the visiting students. During this awareness program, students also visited many experimental labs and were explained about these facilities by the faculties, doctoral students and scientists.

6.2 Activities of Official Language

6.2.0 Official Language Implementation

Institute of Physics, Bhubaneswar is continued its effort in ensuring effective implementation of the Official Language policy of the Government and promoting the progressive of use of Hindi in day to day activities of the Institute.

In compliance with the Official Language, Hindi Fortnight was organized from 14 September, 2019 to 26 September, 2019. During this period, Noting & Drafting Competition, Letter Writing Competition, Essay Competition, Debate Competition, Hindi Typing Competition, were organized for officers and employees of the Institute. Officers and Staff were participated in these competitions with great enthusiasm. All Odisha Hindi Essay Competition was also organized during this period. About 30 students were participated in this competition from different Universities/Colleges across Odisha. Winners were given certificates and cash awards.

To review the progressive use of Hindi in sections, different sections were inspected. Quarterly Meeting of the Official Language Implementation Committee of the Institute were organized regularly. Action was taken on important decision taken in the meetings. Hindi Workshops were organized for motivating the officers and employees for doing their official work in Hindi. During the year, Outcome Budget, Audited Statement of Accounts and Annual Report of the Institute were issued in both Hindi and English.

Hindi Books, Magazines and Newspapers are purchased regularly for its library. Institute is procuring/updating PC software. So that officials can work in Hindi /bilingual form. All communication received in Hindi are entertained and replied in Hindi. 1st and 2nd issue of Rajbhasha house magazine "Bhautiki Kiran" were also published during the year.

Like previous year, Institute bagged the Rajbhasha Shield for 2018- 2019 of DAE for excellent work in Hindi, which was received at All India DAE Rajbhasha Sammelan held on 15.11.2019 at AMD, Hyderabad.

Institute was awarded by the Town Official Language Implementation Committee (Central), Bhubaneswar with second prize for the year of 2018 for effective use of Hindi in the Institute. This award was received on 21st January, 2020 at 66th half-yearly meeting of TOLIC, Bhubaneswar by the Institute.

Institute organized the joint Hindi Workshop on 12.06.2019 jointly with NISER and HWP, Talcher at NISER, Jatani on Incentive Schemes of DAE for using of Hindi in the official works and Hindi software.

A scientific seminar in Hindi was organized by the Institute collaborating with NISER, Heavy Water Plant (Talcher), IREL, Chatrapur and AEES, OSCOM, Chatrapur on 23.08.2019 on "Atomic Energy and Environment".

Institute celebrated the World Hindi Day on 10th January 2020. On this occasion a joint scientific seminar in Hindi was organized at Institute of Life Sciences, Bhubaneswar collaborating with other R&D Institutions on the title of "Role of Scientific & Technical Institutions in preventing the negative effect of climate changes". On behalf of the Institute, 15 Nos. Scientific Officers & Scientific Assistants were participated in this seminar.

(Certificate of merit and prize is handed over by Mrs .Smita S. Mule, Head, TTCD, BARC, Mumbai to the winner of the Hindi Essay Competition)

(Sri N. G. Krishnan, Deputy Secretary, DAE, Prof. Sudhakar Panda, Director, IOP, Dr. A. K. Naik, Registrar, NISER, Sri K.C. Sharma, HWP (Tal), Sri M. Srinivas, IREL during the inaugural programme of the scientific seminar)

(Rajbhasha Shield is received from the Secretary, TOLIC, Bhubaneswar and Deputy Director (Implementation), Department of Official Language, Govt. of India by Prof. Sudhakar Panda, Director, Sri R. K. Rath, and Registrar)

(Prof. Sudhakar Panda, Director is addressing the participants during the inaugural programme of the World Hindi Day-2020)

6.3. International Day of Yoga-2019

On the occasion of International Yoga Day, a yoga camp was organized specially for the women and children on 20.06.2019 at 6.25 P.M. to 8.00 P.M. Most of the children and women were participated

(During the celebration Dr. Biswaranjan Rath, Yogacharya (Left) and Sri R. K. Rath, Registrar (Right) on the Dias)

in this programme. Dr. BiswaranjanRath, Yogacharya, Dev Sanskriti Yoga Bidyalaya, Bhubaneswar delivered a talk on "Yoga for Health". A common yoga practical protocol was also conducted. A meeting was arranged on 21.06.2019 on the occasion of International Day of Yoga. Most of the Faculty Members, Scholars and Staff Members were participated in the meeting. Dr. BiswaranjanRath, Yogacharya, Dev Sanskriti Yoga Bidyalaya, Bhubaneswar delivered a lecture on "the *Importance of Yoga*". Sri Rushi Kumar Rath, Registrar addressed the assembly. Sri BhagabanBehera, Coordinator presented the vote of thanks.

6.4. "Swachhata Hi Seva" campaign -2019

Institute of Physics, Bhubaneswar celebrated the Swachhata Hi Seva Campaign during 11th September to 2nd October, 2019 inside the campus as well as nearby villages. During the period various activities undertaken like awareness campaign, collection of plastic waste and disposal at designated places, awareness programme for villagers and school children etc. the Cleanliness Campaign was announced to emphasize and enhance the importance of hygiene and proper sanitation among the public to pave the way for national development. This campaign was initiated focusing the mobilization of people from all walks of life for achieving the targets of clean India

(Staff Members of the Institute are cleaning the nearby areas of the A. Gs. Office, Bhubaneswar)

and to ensure to make surroundings free from open defecation. It also targeted cleaning of public and tourist places too.

As a part of Swachhata Hi Seva Campaign, Shrama Dann Programme was conducted from 12.9.2019 to 01.10.2019 nearby areas of the Institute to clean the areas of public gathering places, drainage channels and boundary of the holy places. During the activity the local residents instructed not to indulge in throwing of garbage, polythene and glass bottles etc. The removed weed, debris and collected materials were transported to the waste disposal site of the Bhubaneswar Municipal Corporation. About 15 staff members have actively participated in the programme.

On 28.09.2019, Awareness cum Shrama Dann Campaign was conducted at Aranga village, Dist. Khorda. The discussions were opened by Prof. Sudhakar Panda, Director by initiating his remarks that the urge for cleanliness should come from within as "SwachhSwayam " leads to "SwachhSamaj" and finally to "Swachh Bharat". Further he drew attendtion of every one to the potential impacts of Swachhta activities as reflected in Swachhata Bharat=Shrest Bharat". He also stated that every person should be free from social evils of corruption, dishonesty and fraud . He highlighted the importance of Swachhta related activities as a matter of service to the nation. About 100 villagers were participated in this programme.

(Staff Members are cleaning the holy place "Bindusagar" near Lord Lingaraj Temple)

(Shrama Dann activities at "KeluCharanMohapatra Park",Gadhakana, Bhubaneswar)

(Swachhata Awareness cum Shrama Dann activities at Aranga Village)

Swachhata Pakhwada

Institute of Physics, Bhubaneswar celebrated the Swachhata Pakhwada from 16-28 February, 2020. During this pakhwada special activities were conducted like tree plantation, swachhata training and orientation workshop for school children and villagers, shramadaan activities, installation of composting waste machines and discouraging use of plastic in campus.

As a part of the pakhwada, on 18.02.2020 swachhata drive was conducted at Kuruma Archeaeological Budhist site at Konark. 100 villagers and 50 school children were participated in this programme. The total site was cleaned. 74 nos. saplings were planted in the campus. About 250 Nos. school children and 50 teachers were administered swachhata pledge on 28.02.2020 in the Institute.

(Prof. S. M. Yusuf, Director and Sri. R. K. Rath, Registrar with school children at Kuruma during swachhata training and drive campaign on 18.02.2020)

(Prof. S. M. Yusuf, Director is addressing the village people and students at Kuruma regarding swachhata pakhwada)

(Director, Registrar, staff members and villagers are cleaning the Budhist site at Kuruma village)

(Prof. S. M. Yusuf, Director and other staff members are planting a sapling in the Institute campus on 28.02.2020)

6.5 Sports activity for the year 2019-20

Along with the scientific activities, IOP continued to carry out sports and cultural activities to promote different sports and cultural programs as well as to keep all the members physically fit. The IOP Employees Welfare Society conducted various sports and cultural activities in IOP. Also a sports and cultural committee was formed to look after the activities.

The sports and cultural committee members are: Dr. Suresh Kumar Patra (Chairman), Dr. Tapobrata Som, Sri Dillip Kumar Chakraborty, Sri Santosh Kumar Choudhury, Sri Jitendra Kumar Mishra, Sri Sahadev Jena, Sri Biswajit Das and Sri Balakrushna Dash (Secretary). The EB members of IOPEWS are Dr. Suresh Kumar Patra (President), Dr. ArjitSaha, Sri J. K. Mishra, Smt A. Kujur, Sri P. Patra, Sri R. Mahapatra, Sri B. Mohanty (Cultural convener), Sri B. k. Dash (Sport's convener) and Sri B. Behera (Secretary).

Followings are the different activities conducted during the year 2019-20:

1. A Football match was conducted on 15th August, 2019. This was a friendly match between Director's Team (Faculties and Doctoral) and Registrar's Team (Staffs of the Institute). Around 90 spectators were there to enjoy the football match.

2. A friendly Cricket match was also conducted on the occasion of 26th January, 2020. This match was played between Director's Team (Faculties & Doctoral) and Registrar's Team (Staffs). It was a very interesting match. Around 95-viewers joined and made the event successful.

3. Institute also organized the Annual Sports and Cultural Meet in the month of January, 2020. These events started on 09.01.2020 and got completed on 30.01.2020. The total number of events was 17. Around 60 staff members participated in men's events, 32 family members participated in the women's events, and 45 children participated in children's event. Among staffs, 20 volunteers coordinated for a successful completion of the Annual day.

4. During the year 2019-20, IOP players also participated in various competitions of DAE zonal sports and cultural meet, organized by different DAE units. Among them Prof P. V. Satyam and Sri JyotiRanjanBehera were selected for TT, Sri Srikant Mishra for Chess and Miss LipikaSahoo for Carom on the behalf of Konark team to play in the final.

6.6 Other Activities Observed in the Institute

6.7.1 Vigilance Awareness Week-2019

Institute of Physics, Bhubaneswar conducted the Vigilance Awareness Week from 28.10.2019 to 02.11.2019. On 28.10.2019 the programme commenced at 5.00p.m. in the lecture hall of the Institute in the presence of Faculty Members, Scholars and Staff members present on that day. Sri R. K. Rath, Registrar welcomed the gathering and explained the theme of this year "Integrity- a way of life". Vigilance pledge was taken by the faculty members, scholars and staff members. The pledge was

administered by Prof. B. R. Sekhar, Chief Vigilance Officer of the Institute. The pledge taking ceremony was ended with vote of thanks. E-pledge was also administered by the officials through the website of the Institute. During the week, few pamphlets and posters on preventive vigilance activities were displayed on different notice board of the Institute and an essay competition was also organized on the "Integrity – a way of life.

(Prof. B. R. Sekhar, Chief Vigilance Officer is administering the vigilance pledge to the members of Institute during the inaugural programme of the week)

6.7.3. Independence Day Celebration-2019

Institute of Physics celebrated 73rd Independence Day in the campus. The Faculty Members, Scholars, Staff and their family members gathered in the campus for flag hoisting ceremony. Sri R. K.

(Independence Day Celebration-2019: Sri R.K. Rath, Registrar hoisted the national flag on 15th August, 2019 at Institute of Physics, Bhubaneswar)

Rath, Registrar hoisted the national flag at 09:05 A.M. on 15 August, 2019. Soon after the national anthem, Registrar addressed the gathering. In his Independence Day message he elaborated on importance of patriotism and asked everyone to remember the sacrifice made by the martyrs of our nation. Later the campus children gave few patriotic song which was followed by vote of thanks and distribution of sweets

6.7.4. Institute of Physics Employees Welfare Society Activities-2019-20

Institute of Physics Employees Welfare Society (IOPEWS)is an independent body registered under the Society Registration Act 1860 bearing Regd. No. This is a humble initiative from employees of IOP, Bhubaneswar with a motto "Together we grow". IOPEWS undertaken the following welfare

measures for its members as well as their family members during 201-20 as below: "Baisakhi Sandhya" was celebrated on 14.04.2019 in the campus. "Jal Chhatra" was opened for the general public during April-June, 2019. A friendly football match between Academic Team and Administrative Team was organized on 15th August, 2019 in the campus. The annual picnic was arranged at "Bhitarakanika Wildlife Sanctuary" on 25.12.2019 for the members as well as their family members. Foundation Day Celebration was organized on 01.01.2020 in the Institute campus. A friendly cricket match was organized on 26th January, 2020 between Academic Staff and Administrative Staff of the Institute. A free health camp check-up for four wheelers was organized on 25.01.2020 with help of M/s. Go Speedy Go, Bhubaneswar.

6.7.5. Republic Day Celebration-2020

Institute of Physics, Bhubaneswar witnessed the celebration of the 71st Republic Day on the 26th January, 2020. Faculty Members, Scholars, Staff and their Family Members filled with a feeling of patriotism and dedication gathered in front of the Block-A building. The celebration started with the hoisting of the National Flag by the Registrar, Sri R. K. Rath. In his speech in Hindi language, the

Registrar highlighted the importance of the Constitution and its unique features such as Sovereign, Socialist, Secular, Democratic and Republic enshrined in the preamble of the constitution. He also gave an insight on the various accomplishments achieved by the Institute of Physics, Bhubaneswar and motivated the crowd for bringing more laurels for the college through their accomplishments. The speech was followed by the National Anthem, various songs performed by the staff children, giving a glimpse of the diversity in unity of the nation and the Guard of Honour. The program ended with the message to create a great nation through collective efforts from all individual. Sweets were distributed among the gathering.

6.7.6. SPIC-MACAY programme

Institute of Physics, Bhubaneswar organized "Brahma Muhurt" under the agues of SPIC-MACAY, Odisha Chapter on 2nd November 2019 at its Auditorium. The annual overnight classical music concert - Yamini 2019, which hosts eminent dignitaries from the world of classical music. The program was inaugurated by Dr. Kiran Seth, Founder, Spic MacayDr. Seth also talked about the objective of having Yamini as an overnight event, how the event has been attentively curated to start in the evening and conclude by the next morning. . Dr. Seth highlighted how Spic Macay being a voluntary movement has sustained itself in a society where everything has a business perception.

6.7.7. Women Cell Activities

International Women's Day -2020 celebrated at Institute of Physics, Bhubaneswar on 9th March 2020

Two Special Talks have been arranged by Prof. Shikha Varma, chairperson Women-cell of IOP on 9th March 2020 on the occasion of International Women's Day. The talks were given on skype by Advocate (Ms.) Rama Sarode, Socio-legal Consultant and Trainer, Secretary- Sahyog Trust, Pune She gave two talk stitled:

1) Understanding Gender and Equality

2) Learning From "Me Too" movement : Prevention of Sexual Harassment as way forward

About the Speaker: Rama Sarode is the Director of My Growth Zone, an organization that develops digital content. Rama Sarode has 18 years of experience as a trainer on socio-legal issues. She has taken up many initiatives as the Secretary of Sahyog through their legal intervention wing Human rights and Law Defenders. She has worked in various capacities on issues related to women, children, advocacy, HIV, rights of sex workers. She designed and conducted Paralegal training for Prisoners to bring down their depend encyon lawyers. She is the Secretary of Sahyog Trust and works to provide legal assistance to increase the access to justice for vulnerable groups under their intervention wing Human Rights and law defenders (HRLD). Her experience is in areas of prevention of sexual harassment at work place, family law, laws related to women and children and also new linguistic programming. She is the recipient of award from Maharashtra State Gandhi Forum, Sarathi Award and Sundersji Institute's Achiever's Award recognizing her work in the field of human rights.

(Photograph of Mrs. Rama Sarode presenting talk on "Understanding Gender and Equality" at IOP BLOCK-B)

Understanding Gender and Equality

The theme of International Women's Day 2020 is, "I am Generation Equality : Realizing Women's Rights". The theme is in tune with the new multi generational campaign, Generation Equality, of the UN Entity for Gender Equality and the Empowerment of Women. Twenty-five years since the adoption of the Beijing Declaration and Platform for Action—a progressive roadmap for gender equality— we are still at crossroads where many gender related in-equalities exist in India. This session covered the nuances and road maps for achieving gender based equality in our society. After the talk, during the discussion session, it was mentioned that workshops for school children, by trained professional, in this regard will guide our younger generations to have such perspectives from youngage.


(Photograph of Mrs. Rama Sarode presenting talk on " Learning From "Me Too" movement: Prevention of Sexual Harassment as way forward" at IOP and some members)

Learning From "Me Too" movement: Prevention of Sexual Harassment as way forward

The "Me Too" movement has started a wide discussion on variety of issues related to the safety of women at work place. The case of Bhaveri Devi in the 90s shook the conscience of India and brought to discussion the security of women at workplace. Vishakha guidelines were given by the Supreme Court to prevent sexual harassment of women at workplace. Its implementation could, however, strengthen only after the passing of Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act, 2013. In addition to discussing the role of Internal complain committees, the modalities and nuances with some case examples were discussed.

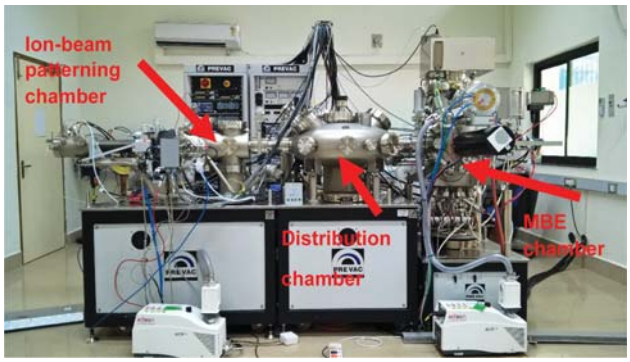
The response for the talks was very enthusiastic and positive. Women Cell of IOP will plan to organize more such discussions and Presentations.

FACILITIES

7.1 MAJOR EXPERIMENTAL FACILITIES

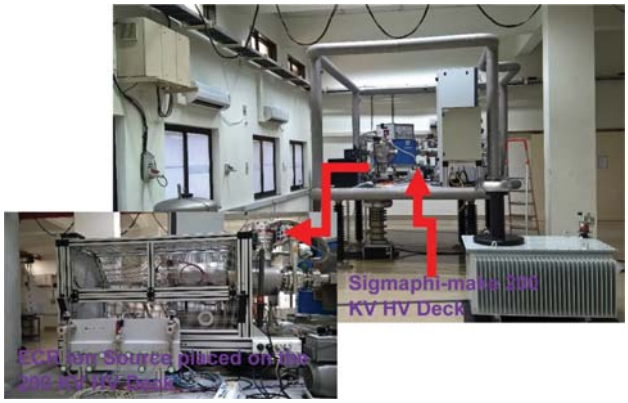
Integrated Low Energy Ion Patterning and UNV Growth System

Recently, we have installed and commissioned a low energy ion patterning unit



integrated with molecular beam epitaxy system for fabrication of self-organized patterned susbstrates, *in-situ* ultrathin films and self-assembled nanostructures to achieve nanoscale functionalities, viz. plasmonics, magnetism and optical properties. This facility is having structural characterization module and we are in the process of adding the in-situ compositional module as well which will make it a unique system in the country.

Development of an ECR ion Source-based low-to-medium energy ion-beam facility

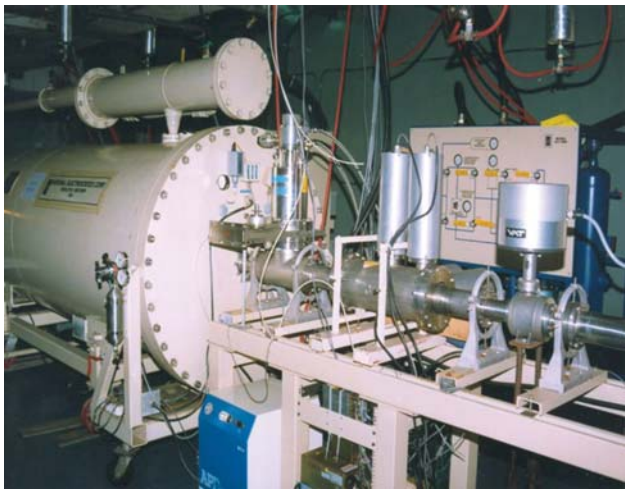


We installed electron cyclotron resonance (ECR) ion source on a 200 KV high voltage deck. This will enable us to accelerate ions to hundreds of keV to a few MeV energy for ion implantation, nanoscale patterning, ion-beam induced epitaxial crystallization, ion-beam mixing, ion-beam shaping, synthesis of embedded nanostructures and so on. This facility will help us bridging the gap of not being able to use inert gas ions (other than helium) and energies below 1 MeV from the existing Pelletron accelerator.

ION BEAM FACILITIES

Ion Beam Laboratory

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

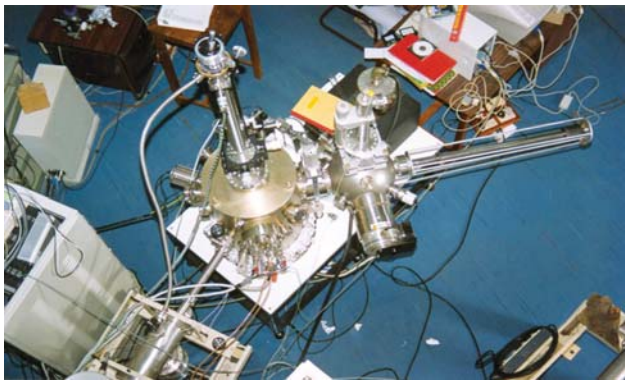
produce positive ions. The most probable charge state for heavy ions (carbon or above) is 3+ for terminal potentials above 2 MV.

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. Radiocarbon AMS is carried out in the -15° beam line. 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 types of experiments that are being carried out in the IBL are mainly ion beam modification and ion beam analysis. These include ion implantation, irradiation, channeling, Rutherford backscattering, and particle induced X-ray emission. The accelerator is also being used for radiocarbon dating by Accelerator Mass Spectrometry (AMS) . The facilities for research in surface sciences include an ultra-high vacuum chamber on the surface physics beam line at IBL which is equipped with a thin film deposition facility, Auger spectroscopy and the low energy electron diffraction (LEED) units.

Ion Beam Analysis Endstation

We have also added an ion beam analysis endstation in the general-purpose beam line at



the Ion Beam Laboratory. This endstation is unique one in the country which is dedicated for user experiments based on ion beam analysis techniques, viz. Rutherford backscattering spectrometry (RBS), RBS-channeling, and elastic recoil detection analysis (ERDA). While RBS is meant for depth profiling of heavy elements, RBS-channeling is capable of analysis of single crystals and epitaxial layers to determine crystalline quality, amorphous layer thickness, degree of disorder and atomic site. In addition, it can be used for accurate determination of thickness of an amorphous thin film, consisting of light elements, deposited on a single crystalline substrate of a relatively heavier element. On the other hand, low-energy ERDA helps in absolute determination of hydrogen and its isotopes in a simultaneous fashion and in a non-destructive way. The system can be upgraded to add proton induced x-ray emission (PIXE) technique for trace elemental analysis in materials. The endstation is equipped with a slam load lock chamber and a rectangular sample holder, which can accommodate more than ten samples at a single go. These eliminate the need for exposing the scattering chamber to the ambient and frequent disruption in experiments. The samples can be precisely positioned in front of

the ion beam with the help of XYZ motors and monitored by a CCD camera. All gate valves and the vacuum pumps are coupled to the interlocking system which rules out meeting a vacuum related accident. In addition, the chamber is equipped with two surface barrier detectors – one dedicated for RBS measurements and the other one for ERDA measurements. They are coupled to the respective set of electronic modules and the data acquisition system is interfaced with a computer.

Ion beam etching induced surface nanostructuring

At Surface Nanostructuring 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. The source is equipped with a differential pumping unit for working at a better chamber vacuum during the ion etching process. The ion source is coupled with a UHV compatible sample processing chamber which is equipped with a load lock chamber and a 5-axes sample manipulator. The sample stage has both low (LN2) and high-temperature (1000°C) stages for creating nanostructures at different sample temperatures. One can measure the target current from the sample stage itself, while the ion current is measured by bringing in a shutter in front of the ion beam path.

MICROSCOPY FACILITEIS

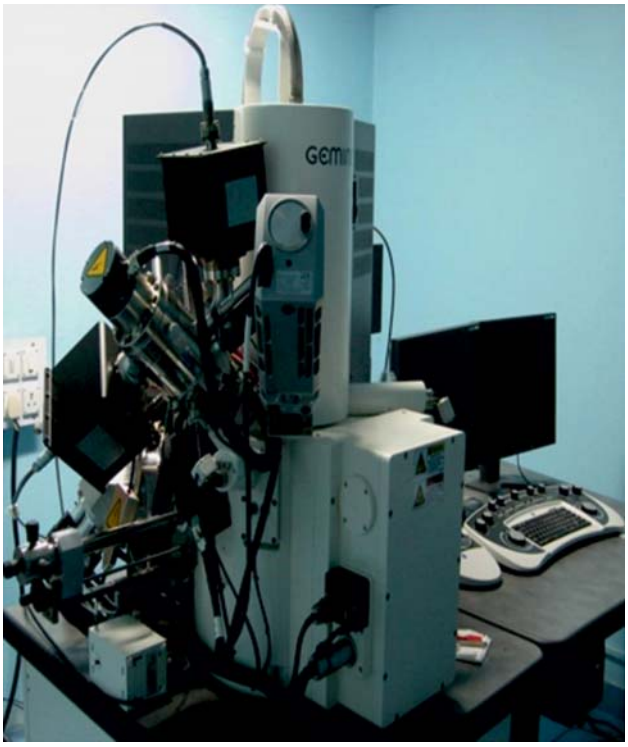
HRTEM Laboratory :

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-to-point resolution of 0.19 nm. For in-situ elemental characterization and compositional analysis, an energy dispersive system using Si(Li) detector (INCA from Oxford, UK) is regularly used. The facility carries out both planar and cross-section TEM analysis of systems. For the specimen preparation, Grinder-cum-polisher, Ultra-Sonic Disc Cutter, Dimple Grinder, Low Speed Diamond Wheel Saw, Wire Saw, Tripod Polisher, Precision Ion Polishing System (PIPS) and Millipore water purifier system facilities are used. Recently, a low-temperature cooling sample stage holder

(cooling with LN2 – minimum temperature achievable is 110 K to room temperature, Model 636 from M/S Gatan Inc.) and a dry pumping system have been installed. the system is also equiped with low and high temperature stages and fast CCD camera to carry out *in-situ* and real time studies.

FEGSEM-FIB facility:



The Cross-Beam facility consists of a field emission based scanning electron microscope (FEGSEM) and a focused ion beam (FIB) system. The facility also has other useful accessories to elemental mapping with x-ray florescence (using energy dispersive spectrometry (EDS)), canning transmission electron microscopy (STEM), e-beam lithography (M/S Raith GmbH) and transmission electron microscopy specimen preparation using lift-out methods. The objective is to understand the combination of bottom-up and top down process in self-assembly of nanostructures. This would help us to create a new methodology that would help to grow atomic scale devices, to understand the structural aspects of nano to micro – scale structures, and to prepare site-specific TEM specimen using the SEM and FIB facilities. The electron beam energy can be varied between 100 eV to 20 keV and the Ga ion beam energy can be varied in the range of 2 – 30 keV. The images can be made with sub-nm resolution while the features can be made of dimensions ~20 nm.

Multi-Mode Scanning Probe Microscope Facility

At IOP we have a Multimode SPM (Scanning Probe Microscope) facility. SPM is

being primarily utilized for the research in the fields of surface science and nanoscience for investigating surface topography, nanostructures, magnetic structures, phase imaging, electrical force imaging, STM, STS and electrochemical STM. The two primary techniques present in our SPM are: Scanning

tunneling Microscope (STM), where the tunneling current between the probe and the sample surface is imaged, and Atomic Force Microscope (AFM), where the forces are imaged. AFM can further operate in two modes viz. Contact mode and Tapping mode. In addition the AFM can be utilize to perform Lateral Force Microscopy (LFM), Force Modulation Microscopy (FMM), Magnetic Force Microscopy (MFM), Electric Force Microscopy (EFM) and Phase Imaging. Studies in Liquid environment are also possible.

In addition, we have a large-area, high-precision AFM setup which is equiped with low Z-axis noise facility. This AFM is mostly

dedicated for studying nanoscale self-organized patterned substates and thin films. Conductive AFM mode offers a gamut of physical properties to be studied. Further it has in-built nano-indentation and nano lithography facilities.

ELECTRON SPECTROSCOPY FACILITIES :

X-Ray Photoelectron Spectroscopy Setup

The present XPS system has a dual X-ray Aode (Mg/Al). The sample can be aligned by a manipulator. Photoelectrons are energy analyzed by a hemispherical mirror analyzer. The system also has the facility for sample annealing and Ar ion sputtering. Sputtering technique can be utilized for doing depth profiling studies. All the experiments are carried out under ultra high vacuum (UHV) conditions at the vacuum of 1x10-10 Torr.

X-ray photons while impinging on the sample surface produce photoelectrons which can be utilized for elemental identification. The kinetic energy distribution of electrons photo-ejected by x-rays from a sample provides a map of the discrete atomic levels, specially the core levels of the constituent atoms with in the material. Another very important aspect of XPS is the ability to distinguish different chemical environments of atoms; these appear in XPS spectra as core level binding energy shifts. The origin of chemical shifts arises from enhanced or reduced electronic screening of electrons due to charge transfer. Small mean free paths of the photo-ejected electrons make XPS very surface sensitive (~1 nm). The technique of XPS is very

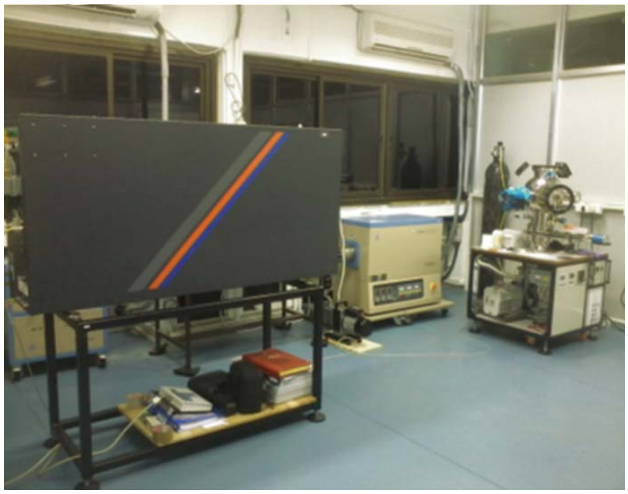
useful in the studies of thin film structures, heterostructures, bulk samples, and even for the studies of biological samples.

ARUPS Laboratory

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. This mu metal UHV system is supplied by M/s Omicron NanoTechnology UK. In angle integrated UPS, we probe the valence band electronic structure on polycrystalline and thin film samples. The angle resolved studies are possible on single crystals. The UPS system consists of a main analysis chamber and a sample preparation chamber, both under 10-11 mbar vacuum conditions. The main chamber is equipped with R3000, Scienta hemispherical analyzer for angle-integrated studies. A movable 65mm hemispherical analyzer, mounted on a 2-axis goniometer is also there in this chamber. These energy analyzers have a typical resolution of around 15 meV. He I (21.2 eV) and He II (40.8 eV) lines from an ultra-violet discharge lamp are used for photo excitation. The analysis chamber is also equipped with a 4-axis sample manipulator-cum cryostat, which can go down to 20K. Facility for performing Low Energy Electron Diffraction (LEED) is also available in the analysis chamber. The sample preparation chamber has facilities for scrap cleaning and evaporating metal films.

THIN FILM GROWTH FACILITIES

Pulsed Laser Deposition (PLD) System



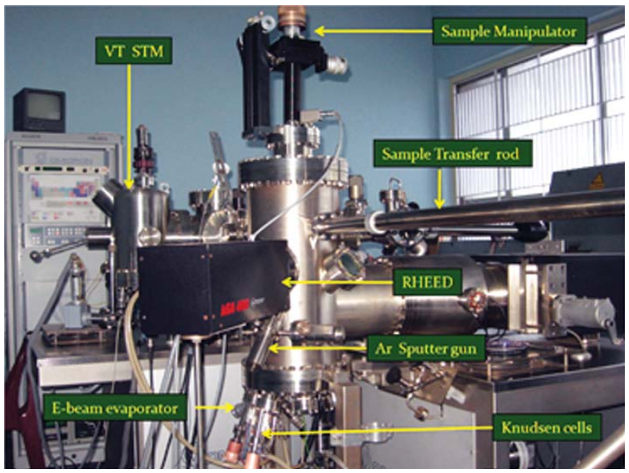
PLD system helps growing epitaxial thin films of various materials albeit the most prefered materials are oxides. The newly installed system was developed in a piece-wise

manner by procuring several modules from different sources. We are depositing epitaxial bi- and multi-layer thin films of superconducting (viz. YBCO) and colosal magneto-resistance (viz. LSMO) on suitable substrates.

DC/RF Magnetron Sputtering

We have installed a pulsed DC/RF magnetron based sputter deposition unit. The unit has four sputter guns where two are

dedicated to operate with pulsed DC supply and the other two are connected to RF power supply. The substrate is made to rotate during film deposition towards having high-quality uniform films. One can put the substrate holder at a high temperature (up to 6000 C) for film growth at elevated temperatures. We have an additional and dedicated gun for deposition of three-dimensional nanostructures by using glancing angle deposition. Further, we have a load lock and a plasma chamber for making nitride and/or oxide layers in vacuum. We can grow thin films of semiconductors, metals, and compounds having a wide variety of morphology and grain size. In turn, their physical properties can also be tuned. Research using this facility is aimed at developing advanced materials having novel structures and



tunable properties. The system is mainly aimed to grow materials on templated substrates and compare change in their physical properties driven by anisotropy in substrate morphology. We have taken up a program to grow thin films and naostructures having applications in solar cell, spintronics, and nanophotonics.

MBE – VTSTM

The ultra clean surfaces are achieved at a vacuum condition better than 1x10-10 mbar pressures (ultra high vacuum, UHV conditions) and appropriate cleaning of surfaces. The Molecular Beam Epitaxy (MBE) – Variable Temperature Scanning Tunneling Microscope (VTSTM) system is a custom designed unit procured from M/S Omicron GmBH, Germany. The facility consists of three Knudsen cells, one e-beam evaporation source, sample manipulator with direct and resistive heating attachments, computer controlled Reflection High Energy Electron Diffraction (RHEED) on-line analysis tool, quartz crystal thickness monitor, Residual Gas Analyzer (RGA), in-situ VTSTM through UHV transfer rods. The facility is being used to study ultra clean surfaces reconstructions on Si(100), Si(110), Si(553) and Si(557) systems, Ge, Au and Ag quantum dots deposited epitaxially on clean silicon surfaces, and epitaxially grown thin films. *In-situ* STM is used to study the atomic and electronic structure of the nanostructures and surface reconstructions. On-line RHEED is used to study the real time growth of epitaxial films

STRUCTURAL PROPERTY MEASUREMENT FACILITIES

High Resolution X-ray Diffractometer (HRXRD)

High Resolution X-Ray defractometer (D8 Discover) can operate in grazing as well as powder XRD mode. The HRXRD system has flexibility with possible combinations of the x-ray source, optics, sample stages, and the detectors. The system consists of goniometer,

short tracks, vertical, 150 mm, 3 kW X-Ray generator, grazing incidence attachment for thin film analysis with parallel beam mirror for better data quality, push plug Göbel Mirror, Cu radiation source with a set of slits for Goebel Mirror, flat LiFmonochromator and set of plug-in slits, Ni filter for Cu radiation, standard sample stage diffracted slit assembly including 2.5° Soller, dynamic scintillation detector, NaI and ICDD data base for phase identification. The diffractometer has the ability to perform a full range of applications for qualitative and quantitative phase identification, crystal structure identification of different samples, X-ray reflectivities crystallite size determination, strain analysis and preferred orientation for established structures. In addition, we have another XRD Setup (D8, Advance), which is also in operation.

XRR and XSW

The X-ray reflectivity and X-ray standing wave measurements are being carried out using indigenously built facility that consists of an 18.0 kW rotating anode (Mo) X-ray source from M/S Rikagu Co. (Japan), a silicon single crystal based monochromator, a 4-circle Huber goniometer for sample mounting and manipulation, two types of detectors (NaI and Si(Li)), a stand alone MCA and associated nuclear electronics for counting and motor controls. The data acquisition and control is done with a computer which uses few add-on cards for the purposes with control software program under Linux operating system.

X-ray reflectivity measurements are being use to study the roughness (with sub-angstrom resolution) at the surface and interfaces and depth profiling (electron densities) many systems such as multilayers, LB films, Polymers, and thin films deposited under various conditions like e-beam evaporation, MBE deposition and spin coating methods. In X-ray standing wave method, standing waves are generated in multilayers (due to long period

nature in self assembled monolayers and multilayer systems) and used to determine the atomic position across the surface and interfaces, such as Pt distribution in Pt/C multilayers.

This facility is also used as high resolution XRD to study strain profile across the interfaces in thin film structures and in epitaxially grown films.

MAGNETIC PROPERTY MEASUREMENT FACILITY

SQUID - VSM

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). To optimize speed and sensitivity, the MPMS SQUID VSM utilizes some analytic techniques employed by vibrating sample magnetometers (VSMs). Specifically, the sample is vibrated at a known frequency and phase sensitive detection is employed for rapid data collection and spurious signal rejection. The size of the signal produced by a sample is not dependent on the frequency of vibration, but only on the magnetic moment of the sample, the vibration amplitude and the design of the SQUID detection circuit. The MPMS SQUID VSM utilizes a superconducting magnet (a solenoid of superconducting wire) to subject

samples to magnetic fields upto 7 Tesla (70 KOe). The squid and magnet is cooled with the help of liquid Helium. Liquid Helium is also used to cool the sample chamber, providing temperature control of samples from 400K down to 1.8K. The SQUID VSM can be used to basically perform M-T,M-H and ac susceptibility measurements at a magnetic field ranging upto 7T and temperature ranging from 4K to 400K.

OPTICAL PROPERTY MEASUREMENT FACILITY

Facility for Investigation of Photo-luminescence and Raman Spectroscopic Properties :

CMPF system was installed in May 2014 and is equipped with water cooled Argon laser. 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. By combining these techniques it is possible to characterize both the vibrational and

electronic properties of materials. The system will be utilized to understand the properties of many semiconductor systems including oxide semiconductors. Our group, in general, is involved in investigating the electronic structure as well as physical, optical, magnetic and chemical properties of surfaces, thin films and nanostructures, grown by a variety of techniques involving Ion sputtering, thermal deposition, vapor deposition. The interaction of DNA and polymers with surfaces and nanostructures is also being actively pursued in the group. Oxide semiconductors are energy storage materials displaying excellent UV and Visible light absorption properties when suitably patterned with nanostructures. Interaction of DNA with oxide surfaces can demonstrate many exciting properties which have technological implications for sensors and bio- implants. Our group has shown that DNA can also act as a tiny sensor of Mercury. These systems will be investigated for their vibrational properties.

7.2 COMPUTER CENTRE

The computer facility of the Institute is dedicated towards providing its services in two categories: Scientific computation and In-House IT facilities. It holds the responsibility of managing IT infrastructure in various sections of the Institute. The centres activity ranges from Server administration, hosting various services to laptop/desktop and user support. The Centre extends its supports in a hybrid environment consisting of various 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. On computational front, 3 (three) clusters are hosted and maintained by the centre.

The centre manages over 200 Desktops, Laptops, Software and License (Mathematica, Matlab, Origin etc), Closed Circuit Television (CCTV) based surveillance systems installed at several offices and laboratories. A number of heavy duty printers are installed at different locations of academic building for general printing over LAN using terminal and through Web using online printing facility. Institute has Polycom setup for meeting its video conferencing requirements.

Institute has leased line Internet connectivity from two Internet Service Providers (ISPs) of 128 Mbps each and 1 Gbps network connectivity by National Knowledge Network (NKN). The Institute operates over its own IP addresses from Indian Registry for Internet Names and Numbers (IRINN). Wireless network is available across all the buildings in campus. Internet facility is extended to residence area through Asynchronous Data Subscriber Line (ADSL).

The administrative work, such as accounting, personnel management, stores management has been computerized. Several software packages such as MSOffice, Wings 200

Net, Tally and multilingual software are in use.

The center conducts training, workshop and awareness programs in relevant areas time to time.

7.3. HPC FACILITY

SAMKHYA (सांख्य): High Performance Computing Facility

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).

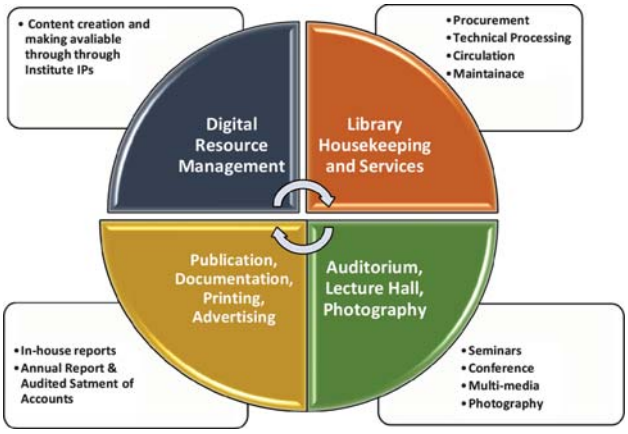
7.4. ANUNET FACILITY

Institute of Physics is a node on ANUNET with the provision to connect other units of DAE directly by VSAT link for voice and data communication. Seismic monitoring equipment has been installed in the Institute and seismic data is being continuously transmitted to Bhabha Atomic Research Centre (BARC) for analysis using ANUNET.

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.

7.5. LIBRARY

There are two branches of the IOP Library, called 'IOP Resource Center' and 'IOP General Library'. IOP Resource Center's mandate is to select, acquire, process and disseminate both



print and electronic / digital scientific and technical resources in a timely manner for the information needs of the Institute's research community along with other associated stakeholders.On the other hand, IOP General Library aims to serve the requirement of the IOP community and to nurture the reading habit. Apart from the day-today Library services, IOP Library also provides associated facilities namely 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 facility is available to the members of the Institute as well as members

from other academic institutions of the State especially Institutes under Department of Higher Education of Government of Odisha. The detailed holdings of the Library can be accessible from Library Portal @ http://www.iopb.res.in/~library/ebooks.php.

The Library facility is available to the members of the Institute as well as members from other academic institutions. The Library holdings include 16,684 books, 6000+ e-books, and 23,643 bound Journals as its own collection. The Library subscribes to 135 Journals, 30 Magazines and 13 number of Newspapers. The Library has also acquired IOP (UK), John Wiley, Springer Physics and Astronomy, Scientific American, World Scientific, Annual Reviews Archives (OJA) perpetual access right to the back files containing all articles published since Volume 1 in electronic format. Library also subscribed two e-Books on Lecture Notes in Mathematics and Physics series from Volume1 with perpetual access right to back files, and full archives are containing all articles. Being a core member of the Department of Atomic Energy (DAE) Consortium with Elsevier Science, Library is also getting access to 2000+ Elsevier journals with access from 1995 onwards electronically. Besides this, Library being a part of e-ShodhSindhu (eSS) consortium, have access to World eBook Library (WeL) & South Asia Archive under NATIONAL DIGITAL LIBRARY OF INDIA. World eBook Library (WeL) is the world's largest collection of primary source ebooks consist of 40 lacs+ e-books and millions of journal articles with unlimited access and downloading. The South Asia Archive (a wealth of interdisciplinary content) provides online access to millions of pages of rare primary and secondary sources from across the social sciences and humanities.

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

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

The Library is housed in a centrally air-conditioned building which is open round the clock for the convenience of the users. Library also provides reprographic services and handles the publication, printing and advertisement division of Institute. 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 perodic interval. The Library also supports many extension services namely Study Tour of LIS students, Project/Dissertaions of LIS students.

Publications by Library Staff:

RESEARCH PAPER(S) PUBLISHED IN JOURNALS:

- Sahoo, J., **Mohanty, B.** *(Corresponding Author),* Biswal, O., Dash, N, K. and Sahu, J. K. (2019). Authorship trend and content analysis A case study on highly cited articles in library and information science journals. *Performance Measurement and Metrics (PMM)*, Vol. 21, No.1, 33-51. DOI: https://doi.org/10.1108/PMM-06-2019-0021

OTHER THAN RESEARCH PAPERS:

1. Dash, N. K., Sahoo, J., **Mohanty, B.** (2019). *The Revelation of Relationship between Library Transactions & Students Academic Performanc*e in 12th International CALIBER 2019 on "LIBRARY 2030: Moving Towards Smart Technologies, Services & Resources" organised by INFLIBNET & KIIT; 28-30 Nov'19, BBSR; ISBN- 978-93-81232-09-5, p. 386-402,
2. **Mohanty, B.** (2020). Delivered talk on "Freelance Librarian' as invited speaker in the National Seminar on "Changing Landscape of Libraries In Digital Age" at P.G.Dept. Of Library and Information Science, Sambalpur University, 6-7 February 2020.
3. Conducted Seminar on "Current trendsin Digital Library" as General Secretary, Odisha Library Academy in Digital Library at RCM Bhubaneswar in association with Informatics India Ltd. on 11-8-2019.

(LIS students' Study tour to IOP Library)

(Library induction to Ph.D. batch 2019)

(Farwell to Mr. D. K. Chakravarty by Library Staff & family members)

7.6 AUDITORIUM

IOP has a beautiful auditorium in its campus for organizing Colloquiums, Seminars, Workshops, Conferences, Cultural activities, Social programs regularly. This auditorium can easily accommodate 330+ people. It has all the high-quality amenities to organize above mentioned events.

PERSONNEL

PERSONNEL

DIRECTORS

1. Prof. S. M. Yusuf
Director (From 23.01.2020)

2. Prof. Sudhakar Panda
Director (Till 22.01.2020)

8.1. List of Faculty members and their research specialization

1. **Prof. Arun M. Jayannavar**
   Sr. Professor
   Condensed Matter Physics *(Theory)*
2. **Prof. S. M. Bhattacharjee***(upto 01.05.2019)*
   Sr. Professor
   Condensed Matter Physics *(Theory)*
3. **Prof. Ajit M. Srivastava**
   Professor
   High Energy Physics *(Theory)*
4. **Prof. Shikha Varma**
   Professor
   Condensed Matter Physics *(Experiment)*
5. **Prof. Pankaj Agrawal**
   Professor
   High Energy Physics *(Theory)*
6. **Prof. Biju Raja Sekhar**
   Professor
   Condensed Matter Physics *(Experiment)*
7. **Prof. P. V. Satyam**
   (Lien from 18.02.2020)
   Professor
   Condensed Matter Physics *(Experiment)*
8. **Prof. Sudipta Mukherji**
   Professor
   High Energy Physics *(Theory)*
9. **Prof. Suresh K. Patra**
   Professor
   Nuclear Physics *(Theory)*
10. **Prof. Tapobrata Som**
    Professor
    Condensed Matter Physics *(Experiment)*
11. **Prof. Pradip Kumar Sahu**
    Professor
    Nuclear **Physic**s (Theory)
12. **Dr. Goutam Tripathy**
    Reader-F
    Condensed Matter Physics *(Theory)*
13. **Dr. Dinesh Topwal**
    Reader – F
    Condensed Matter Physics *(Experiment)*
14. **Dr. Sanjib Kumar Agarwalla**
    Associate Professor
    High Energy Physics *(Theory)*
15. **Dr. Arijit Saha**
    Reader - F
    Condensed Matter Physics *(Theory)*
16. **Dr. Saptarshi Mandal**
    Reader - F
    Condensed Matter Physics *(Theory)*
17. **Dr. Satyaprakash Sahoo**
    Reader - F
    Condensed Matter Physics *(Experiment)*
18. **Dr. Aruna Kumar Nayak**
    Reader-F
    High Energy Physics *(Experiment)*

19. **Dr. Debashis Chaudhuri**
Reader - F
Condensed Matter Physics *(Theory)*

20. **Prof. Shamik Banerjee**
Reader - F
High Energy Physics *(Theory)*

21. **Dr. Debakanta Samal**
Reader - F
Condensed Matter Physics *(Experiment)*

22. **Dr. Debottam Das**
Reader - F
High Energy Physics *(Theory)*

23. **Dr. M. M. Mitra**
Reader - F
High Energy Physics *(Theory)*

24. **Dr. Kirtiman Ghosh**
Reader - F
High Energy Physics *(Theory)*

8.2. National Post-Doctoral Fellow (NPDF)

1. Shidharth S. Ram *(Joined on 4th April, 2017* under Prof. P. V. Satyam)
2. Soumya C(Joined on 11th February, 2020 under Assoc. Prof. S. K.Agarwalla)

8.3. Post-Doctoral Fellows

1. Dr. Shakti Shankar Acharya
2. Dr. Bhaskara Chandra Behera
3. Dr. Soumya C (till 03.01.2020)
4. Dr. Tapoja Jha
5. Dr. Minati Biswal
6. Dr. Nirakar Sahoo
7. Dr. Biplab Bhattacahrjee
8. Dr. Sudheer
9. Dr. Sitendra Pratap Kashyap
10. Dr. Manpreet Kaur

8.4. Research Assistant

1. Amit Kumar
2. Biswajit Das
3. Ganesh Chandra Paul
4. Partha Paul
5. Sujaya Shil
6. Vijigiri Vikas

8.5. Doctoral Scholars

1. Abhishek Roy
2. Aisha Khatun
3. Ankit Kumar
4. Arnob Kumar Ghosh
5. Arpan Sinha
6. Chitrak Karan
7. Harish Chandra Das
8. Mousam Charan Sahu
9. Pragyanprasu Swain
10. Ritam Kundu
11. Sachin Chauhan
12. Sameer Kumar Mallik
13. Sandhyarani Sahoo
14. Siddharth Prasad Maharathy
15. Sudipta Das
16. Bibhabasu De
17. Chinmaya Kumar Panda
18. Diwakar
19. Pranjal Pandey
20. Rupam Mandal
21. Saiyad Ashanujjaman
22. Rojalin Padhan
23. Rahul Roy
24. Gupteswar Sabat,

25. Abhisek Bag
26. Avnish
27. Debjyoti Majumdar
28. Sayan Jana
29. Subhadip Jana
30. Vinaykrishnan M.B.
31. Sudarshan Saha
32. Alapan Dutta
33. Amir Shee
34. Atanu Maity
35. Dibyendu Rana
36. Dilruba Hasina
37. Honey Khindri (INO Proj. Student)
38. Anil Kumar (INO Proj. Student)
39. Sadashiv Sahoo (INO Proj. Student)

8.6. 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. Baula Tudu
3. Bhagaban Behera
4. Soubhagya Laxmi Das
5. Ghanashyam Pradhan
6. Samarendra Das
7. Pradip Kumar Naik
8. Gandharba Behera

(iv) Transport

1. Pramod Kumar Senapati
2. Sanatan Jena
3. Sarat Chandra Pradhan
4. Jahangir Khan
5. D. Govinda Rao *(from 17.02.2020)*

(v) Accounts

1. Debendranath Sahoo *(from 05.12.2019)*
2. Jitendra Kumar Mishra
3. Bhaskar Mishra
4. Prativa Choudhury
5. Sahadev Jena
6. Rajesh Mohapatra
7. Priyabrata Patra
8. Jyoti Ranjan Behera
9. Bijaya Kumar Das
10. Bansidhar Panigrahi

(vi) Stores & Purchase Section

1. Aviram Sahoo
2. Raj Kumar Sahoo
3. Sahadev Jena
4. Keshaba Chandra Dakua

(vii) EPABX

1. Arakhita Sahoo
2. Ghanashyam Naik
3. Daitari Das

(viii) Campus Maintenance (Electrical/Civil/AC/Horticulture)

1. Sanjib Kumar Sahu
2. Arun Kanta Dash
3. Debaraj Bhuyan
4. Bansidhar Behera
5. Brundaban Mohanty
6. Deba Prasad Nanda
7. Naba Kishore Jhankar
8. Purna Ch. Maharana *(until 31.07.2019)*
9. Pabani Bastia *(until 30.06.2019)*
10. Umesh Ch. Pradhan
11. Biswa Ranjan Behera
12. Kapila Pradhan
13. Martin Pradhan
14. Chandra Mohan Hansdah
15. Saroj Kumar Jena.
16. Gangadhar Hembram
17. Tikan Kumar Parida
18. Banamali Pradhan
19. Biswanath Swain
20. Bijaya Kumar Swain
21. Sanatan Pradhan
22. Bhaskara Mallick
23. Kulamani Ojha
24. Pitabas Barik
25. Dhoba Naik
26. Charan Bhoi
27. Jatindra Nath Bastia
28. Babuli Naik *(until 30.04.2019)*
29. Ramesh Kumar Patnaik

(ix) Library

1. Dr. Basudev Mohanty
2. Dillip Ku. Chakraborty *(upto 30.4.2019)*
3. Ajita Kumari Kujur
4. Rama Chandra Hansdah
5. Kisan Kumar Sahoo
6. Kailash Chandra Jena
7. Basanta Kumar Naik

(x) Computer Centre

1. M. Siddhabhatti
2. Nageswari Majhi

(xi) Laboratory

1. Sanjib Kumar Sahu
2. Anup Kumar Behera *(upto 30.04.2019)*
3. Sachindra Nath Sarangi
4. Khirod Chandra Patra
5. Madhusudan Majhi
6. Ramarani Dash
7. Santosh Kumar Choudhury
8. Biswajit Mallick
9. Pratap Kumar Biswal
10. Bala Krushna Dash
11. Soumya Ranjan Mohanty
12. Purna Chandra Marandi
13. Srikanta Mishra
14. Ranjan Kumar Sahoo

(xii) Workshop

1. Subhabrata Tripathy
2. Ramakanta Nayak
3. Rabi Narayan Naik

8.7. LIST OF NEW MEMBERS

Sri Debendranath Sahoo
Jr. Accounts Officer
Joined on 05.12.2019

Sri D. Govindo Rao
Driver
Joined on 17.02.2020

8.8. LIST OF RETIRED MEMBERS

Name: Shri Anup Kumar Behera
Designation: Scientific Officer-D
DoJ: 01.03.1983
DoR: 30.04.2019

Name: Shri Babuli Naik
Designation: MTS-B
DoJ: 10.07.1992
DoR: 30.04.2019

Name: Shri Dilip Kumar Chakravarty
Designation: Scientific Assistant-F
DoJ: 07.05.1982
DoR: 30.04.2019

Name: Prof. S.M. Bhattacharjee
Designation: Senior Professor
DoJ: 08.09.1988
DoR: 01.05.2019

Name: Shri Pabani Bastia
Designation: Tradesman-F
DoJ: 01.08.1983
DoR: 30.06.2019

Name: Shri Purna Chandra Maharana
Designation: Tradesman-G
DoJ: 03.05.1984
DoR: 31.07.2019

Name: Shri Banamali Pradhan
Designation: MTS-B
DoJ: 03.07.1990
DoR: 30.09.2019

Name: Shri Ravi Narayan Naik
Designation: Tradesman-F
DoJ: 12.01.1996
DoR: 31.10.2019

Name: Shri Ghanashyam Naik
Designation: Tradesman-F
DoJ: 21.05.1982
DoR: 31.10.2019

Name: Shri Jitendra Kumar Mishra
Designation: Sr. Assistant
DoJ: 12.04.1982
DoR: 31.03.2020

परीक्षित लेखा विवरण

AUDITED STATEMENT OF ACCOUNTS

2019-20

भौतिकी संस्थान

INSTITUTE OF PHYSICS

भुवनेश्वर, ओडिशा

BHUBANESWAR, ODISHA

पार्थ एस. मिश्र एंड कंपनी/PARTHA S MISHRA & CO.

सनदी लेखाकारों / CHARTERED ACCOUNTANTS

जीए-140, निलाद्री विहार / GA-140, NILADRI VIHAR

भुवनेश्वर / BHUBANESWAR – 751 021

मोबाइल / MOBILE: 8637260078

Contents

PARTHA S MISHRA & CO
Chartered Accountant

INDEPENDENT AUDITOR'S REPORT

To,
The Director
The Institute of Physics
Bhubaneswar

We have audited the accompanying financial statements of **INSTITUTE OF PHYSICS** which comprises the Balance Sheet as at 31st march 2020 and the Statement of Income and Expenditure and Statement of Receipt and Payments for the year ended as on that date.

Management's Responsibility for the Financial Statements

Management is responsible for the preparation of these financial Statements that give a true and fair view of the financial position, financial performance of the Institute 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 plan and perform the audit to obtain reasonable assurance about whether the financial statements are free from material misstatement.

Plot No. GA-140, Ground Floor, Niladri Vihar, Bhubaneswar-751021, Ph. : 0674-2720247, Mob. :+91-9437044824 / 9776044824, 9439880419
E-mail : parthamishra1@yahoo.com / psmefiling@gmail.com / psm_caoff@rediffmail.com

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 those risk assessments , the auditors considers internal controls relevant to the Entity's 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. IAS 10 regarding to fixed assets and As6 for depreciation have not been followed. There was no fixed asset 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.

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

Matter of emphasis:

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

- Balances of advances and liabilities recognized from third Parties are subjects to confirmation.

We are not qualifying our report on the above points.

Based on the above, in our opinion and to the best of our information and according to the explanations given to us, the financial statements read with the Accounting policies and notes on accounts and the separate report as annexed herewith the report, give 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 Institute as at March 31, 2020
b. In the case of the statement of income and expenditure, of the deficit of the Institute for the year ended on that date.
c. In case of statement of Receipt and Payments, the receipts and payments for the year ended on that date.

Report on 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 purpose of our audit and have found them to be satisfactory.
b. In our opinion proper books of account as required by law have been kept by the Institute, so far as appears from our examination of those books.
c. The Balance sheet, Statement of Income and Expenditure & Receipts & Payment Statement dealt with by this report are in agreement with the books of accounts.

For PARTHA S. MISHRA & CO.
Chartered Accountants
Sanjaya Kumar Patra
CA S.K. Patra (FCA, DISA)
Partner, M. No-301929
FRN: 324467E

UDIN: 20301929AAAADT5330

Date: 22/10/2020
Place: Bhubaneswar

PARTHA S MISHRA & CO
Chartered Accountant

To,
The Registrar,
Institute of Physics,
BHubaneswar.

Dt.22.01.2021

Sub: Maintenance of Fixed Asset Register by the Institute of Physics, Bhubaneswar.

Sir,

We, M/s Partha S Mishra & Co, Chartered Accountants, are the Statutory Auditor of Institute of Physics for the Financial Year 2019-20. On the basis of verification of books of accounts produced before us, we hereby confirms that the Organisation has updated its Fixed Asset Register up to the Financial Year 2017-18.

The same may be noted for record purpose and our qualification in the audit report is complied with to that extent.

Thanks & Regards

For M/s Partha S Mishra & Co.
Chartered Accountants

Sanjaya kumar Patra

CA. S K Patra
Partner
Mem No. 301929
FRN: 324467E

Plot No. GA-140, Ground Floor, Niladri Vihar, Bhubaneswar-751021, Ph. : 0674-2720247, Mob. :+91-9437044824 / 9776044824, 9439880419
E-mail : parthamishra1@yahoo.com / psmefiling@gmail.com / psm_caoff@rediffmail.com

ANNEXURE TO THE AUDIT REPORT (REFERED TO IN OUR REPORT ON EVEN DATE)

AUDIT OBSERVATIONS ON THE ACCOUNTS OF INSTITUTE OF PHYSICS FOR THE FIANCIAL YEAR 2019-20

1) Maintenance of books of accounts:

The following manual books of accounts are maintained in the year 2019-20

a) Cash cum bank book
b) Cheque issue register
c) Staff advance register
d) Security deposit register
e) TDS register

2) Others:

a) Advances to staff unadjusted for more than 3 months were found in the following cases. The same should be adjusted /recovered at an earliest.

Sl.	Date	Name	Purpose	Amount(Rs.)
1	29/05/2018	M. M. Mondal	Alice	1,12,000.00
2	29/08/2019	Saroj Kumar Jena	Civil Maintenance	27,000.00
3	26/09/2019	Khirod Chandra Patra	Domestic Travel	30,500.00
4	04/01/2019	D. Topwal (IIT Bombay)	Laboratory Maintenance	10,714.40
5	09/10/2019	D. Topwal (XRD shift)	Laboratory Maintenance	15,000.00
6	19/12/2019	Ghanashyam Pradhan	Postage	20,000.00

b) The STDR aginst L/C are pending as on 31.03.2020 for more than one (1) month as stipulated by IOP guideline. Some of such instances are given below.

Sl.	Name	Date of Advance	Amount
1	Testronix Asia Ltd,USA	27.04.2018	3,70,833
2	Heidelberg instruments , Laser based Lithography	30.10.2019	23,59,000

c) During the course of audit, it is noted that GST of Rs.17,479.00 collected in the year 2017-18 is not yet refunded.

INSTITUTE OF PHYSICS, BHUBANESWAR

BALANCE SHEET AS AT 31ST MARCH 2020

(Amount - Rs.)

CORPUS/ CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year
CORPUS/ CAPITAL FUND	1	64,15,57,802	60,45,43,580
RESERVES AND SURPLUS	2	-	-
EARMARKED/ ENDOWMENT FUNDS	3	1,13,65,499	90,84,957
SECURED LOANS AND BORROWINGS	4	-	-
UNSECURED LOANS AND BORROWINGS	5	-	-
DEFFERED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	15,26,57,687	18,71,95,602
TOTAL		**80,55,80,988**	**80,08,24,139**
ASSETS			
FIXED ASSETS	8	68,07,41,660	73,96,15,867
INVESTMENTS FROM EARMARKED/ ENDOWMENT FUNDS	9	-	-
INVESTMENTS OTHERS	10	-	-
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	12,48,39,328	6,12,08,272
TOTAL		**80,55,80,988**	**80,08,24,139**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

In terms of our report of even date annexed

For PARTHA S. MISHRA & CO.
Chartered Accountants
Sanjaya Kumar Patra
CA S.K. Patra (FCA, DISA)
Partner, M. No-301929

Place : Bhubaneswar
Date : 22-10-2020

22/10/20
कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
भौतिकी संस्थान / Institute of Physics
भुवनेश्वर / Bhubaneswar

22/10/2020
रजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

Md Zuyut
22.10.2020
INSTITUTE OF PHYSICS
BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

STATEMENT OF INCOME AND EXPENDITURE FOR THE PERIOD/YEAR ENDED 31ST MARCH 2020

(Amount - Rs.)

	Schedule	Current Year	Previous Year
INCOME			
Income from sale or services	12	-	-
Grants/ Subsidies	13	36,68,00,000	30,10,00,000
Fees/ Subscriptions	14	-	-
Income from investments	15	-	-
Income from royalty, Publication etc	16	-	-
Interest Earned	17	5,15,577	4,39,362
Other Income	18	29,54,329	27,10,305
Increase decrease in stock of finised goods/ WIP	19	-	-
TOTAL (A)		**37,02,69,906**	**30,41,49,667**
EXPENDITURE			
Establishment Expenses	20	20,95,77,244	23,19,67,999
Other Administrative Expenses etc.	21	9,55,21,229	7,23,42,928
Expenditure on grants Subsidies etc (Plan grant Surrendered)	22	-	-
Interest Paid	23	-	-
Depreciation (Corresponding to Schedule 8)		8,81,57,211	12,24,16,661
TOTAL (B)		**39,32,55,684**	**42,67,27,588**
Balance being excess of Expenditure over Income (A-B)		(2,29,85,778)	(12,25,77,921)
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/ CAPITAL FUND		**(2,29,85,778)**	**(12,25,77,921)**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

In terms of our report of even date annexed

For PARTHA S. MISHRA & CO.
Chartered Accountants
Sanjaya Kumar Patra
CA S.K. Patra (FCA, DISA)
Partner, M. No-301929

Place : Bhubaneswar
Date : 22-10-2020

22/10/20
कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
भौतिकी संस्थान / Institute of Physics
भुवनेश्वर / Bhubaneswar

22/10/2020
रजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

Md. Zuyat 22.10.2020
निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 1 - CORPUS/CAPITAL FUND				
Balances as at the beginning of the year		60,45,43,580		69,71,21,501
Add : Contributions towards Corpus/Capital Fund	6,00,00,000		3,00,00,000	
Add/(Deduct) : Balance of Income/(Expenditure) transferred from Income & expenditure Account	(2,29,85,778)	3,70,14,222	(12,25,77,921)	(9,25,77,921)
Balances as at the year end		**64,15,57,802**		**60,45,43,580**

22/10/20
कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
भौतिकी संस्थान/Institute of Physics
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Md. Yusuf 22.10.2020
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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2020

(Amount - Rs.)

	Current Year				Previous Year
SCHEDULE 3 - EARMARKED/ENDOWMENT FUNDS	OB	Receipt	Payment	CB	
1. L. K. Panda Memorial Fellowship	2,17,541	8,360	5,000	2,20,901	2,17,541
2. TPSC Account	8,589	1,00,742	7,915	1,01,416	8,589
3. Inspire Grant of Dr. S.K.Agarwalla	16,406	386	14,000	2,792	16,406
4. Inspire Grant of Dr. Manimala Mitra	5,15,509	16,347	3,20,359	2,11,497	5,15,509
5. NPDF of Dr. S. S. Ram	2,68,882	3,735	2,72,617	-	2,68,882
6. NPDF of Dr. R. K. Bommali	8,69,077	16,554	8,85,631	-	8,69,077
7. NPDF of Dr. P. Dutta	40,598	1,071	-	41,669	40,598
9. JC Bose Grant of Prof. A. M. Jayannavar	8,58,668	24,21,311	18,13,426	14,66,553	8,58,668
10. JC Bose Grant of Prof. S. M. Bhattacharjee	3,00,609	6,623	3,04,690	2,542	3,00,609
11. Ramanujan Fellowship Grant of Dr. A. K. Nayak	3,92,281	4,12,922	6,28,695	1,76,508	3,92,281
12. INSA Grant of Prof. J. Maharana	-	1,00,928	90,771	10,157	-
13. BI IFCC Grant of Dr. P. K. Sahu	6,68,980	33,830	36,867	6,65,943	6,68,980
14. UGC-CSR Grant	1,84,244	8,664	-	1,92,908	1,84,244
15. Woman Scientist Grant of Dr. S. Bandopadhyay	77,165	7,52,584	8,20,267	9,482	77,165
16. DST Grant of Prof. S. Varma	2,88,215	4,16,214	3,35,302	3,69,127	2,88,215
17. SERB Grant of Dr. D. Chaudhuri	29,076	15,36,022	2,95,244	12,69,854	29,076
18. Max-Plank Grant of Dr. D. Samal	26,11,990	5,92,791	14,05,292	17,99,489	26,11,990
21. CSIR Pool Scientist Programme	7,546	6,456	6,287	7,715	7,546
23. INSA Young Scientist - SK Agarwalla	2,06,450	3,65,568	3,30,949	2,41,069	2,06,450
24. NALCO Project - PV Satyam	15,23,131	13,53,007	16,30,694	12,45,444	15,23,131
25. Mobility Fellowship - Kuntala Bhattacharjee	-	35,12,176	11,14,536	23,97,640	-
26. Quantum Information Technologies - P. Agarwal	-	7,66,243	2,75,887	4,90,356	-
27. PFMS	-	12,42,437	8,00,000	4,42,437	-
TOTAL:	**90,84,957**	**1,36,74,971**	**1,13,94,429**	**1,13,65,499**	**90,84,957**

22/10/20
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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS:				
A. CURRENT LIABILITIES				
1. Statutory Liabilities:				
NPS Recovery Payable	-		26,013	
Professional Tax Payable (Plan + Non-Plan)	30,650		(325)	
TDS Salary Payable	(2,240)		67,490	
TDS Non-Salary Payable	8,764		13,588	
Plan GST Payable	(7,212)		51,450	
Plan TDS Payable	-		43,190	
GST Recovery Payable	35,916		1,51,915	
GSLI Premium Payable	150		150	
Interest Payable to DAE (NP)	4,05,287		3,66,941	
Interest Payable to DAE (Plan)	10,63,227		16,06,339	
WCT Recovery Payable	-		89,013	
		15,34,542		24,15,764
2. Other Liabilities:				
Earnest money Deposit	13,46,390		22,30,530	
Caution money from Scholars	13,600		12,000	
GSLI Claim Payable	42,699		28,223	
Project Grant Payable	17,67,000		50,00,000	
Provision for Expenses	1,23,38,674		3,20,35,013	
SSB Fellowship Payable	45,000		-	
IOPEWS Recovery Payable	8,475		-	
IPEA Recovery Payable	12,400		32,090	
Gratuity Payable	4,61,813		2,87,123	
Non-Plan Recovery Payable	3,200		3,200	
Security Deposit - contractors (Plan + Non-Plan)	15,11,073		16,11,804	
		1,75,50,324		4,12,39,983
TOTAL (A)		**1,90,84,866**		**4,36,55,747**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS (Contd....):				
B. PROVISIONS				
1. Gratuity		6,44,25,198		7,32,20,096
2. Accumulated Leave Encashment		6,91,47,623		7,03,19,759
TOTAL (B)		**13,35,72,821**		**14,35,39,855**
TOTAL (A + B)		**15,26,57,687**		**18,71,95,602**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2020

(Amount - Rs.)

SCHEDULE 8 - FIXED ASSETS

DESCRIPTION	GROSS BLOCK				Residual Value	DEPRECIATION					NET BLOCK	
	Cost/valuation As at beginning of the year	Additions during the year	Deductions during the year	Cost/valuation at the year-end		As at the beginning of the year	Rate %	For the year	Deductions / Adjustments during the year	Total up to the Year-end	As at the Current year-end	As at the Previous year-end
A. FIXED ASSETS (PLAN):												
1. LAND												
a) Leasehold	50,00,000	-	-	50,00,000	-	-		-	-	-	50,00,000	50,00,000
2. BUILDINGS												
a) On Leasehold Land	21,06,66,379	-	-	21,06,66,379	1,05,49,319	5,02,41,535	1.63	34,39,078	-	5,36,80,613	15,73,05,766	16,04,24,844
3. ROADS	65,48,158	-	-	65,48,158	3,27,408	56,86,073	19.00	5,34,677	-	62,20,750	3,27,408	8,62,085
4. PLANT MACHINERY & EQUIPMENT	87,12,50,862	2,75,98,920	-	89,88,49,782	4,49,42,489	40,79,89,895	5.28	4,74,59,268	-	45,54,49,163	44,34,00,619	46,32,60,967
5. COMPUTER/PERIPHERALS	14,81,34,970	15,53,104	-	14,96,88,074	74,84,404	13,63,48,339	16.21	58,55,331	-	14,22,03,670	74,84,404	1,17,86,631
6. Capital Work in Progress	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL (A)	**1,24,19,20,369**	**2,91,52,024**	**-**	**1,27,10,72,393**	**6,33,03,620**	**60,02,65,842**		**5,72,88,354**	**-**	**65,75,54,196**	**61,35,18,197**	**64,16,54,527**
B. FIXED ASSETS (NON-PLAN)												
1. VEHICLES	28,70,817	-	-	28,70,817	1,43,541	22,04,865	9.50	2,72,728	-	24,77,593	3,93,224	6,65,952
2. FURNITURE, FIXTURES	2,33,94,462	27,854	-	2,34,22,316	11,71,116	2,12,35,861	9.50	10,15,339	-	2,22,51,200	11,71,116	21,58,601
3. OFFICE EQUIPMENT	12,93,51,739	1,03,126	-	12,94,54,865	64,72,743	12,26,69,048	9.50	3,13,074	-	12,29,82,122	64,72,743	66,82,691
4. ELECTRIC INSTALLATIONS	5,09,20,593	-	-	5,09,20,593	25,46,030	1,17,39,535	6.33	32,23,274	-	1,49,62,809	3,59,57,784	3,91,81,058
5. LIBRARY BOOKS	46,45,71,913	-	-	46,45,71,913	2,32,28,596	41,52,98,875	9.50	2,60,44,442	-	44,13,43,317	2,32,28,596	4,92,73,038
TOTAL (B)	**67,11,09,524**	**1,30,980**	**-**	**67,12,40,504**	**3,35,62,026**	**57,31,48,184**		**3,08,68,857**	**-**	**60,40,17,041**	**6,72,23,463**	**9,79,61,340**
TOTAL OF CURRENT YEAR (A+B)	**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**
PREVIOUS YEAR	1,82,08,13,912	9,22,15,981	-	1,91,30,29,893	9,56,51,495	1,05,09,97,365		12,24,16,661	-	1,17,34,14,026	73,96,15,867	76,98,16,547

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.				
A. CURRENT ASSETS:				
1. Inventories:				
a) Electrical Fittings Stock	13,43,264		12,60,373	
b) Office Stationery	2,72,932		3,18,811	
c) Computer Stationery	6,13,440		1,56,410	
d) Diesel Stock	99,631		85,026	
e) Carpentry Material Stock	52,104		27,866	
f) Workshop Spares	3,37,443		4,02,602	
g) PH Material Stock	1,20,623		35,415	
		28,39,437		22,86,503
2. Cash balances in hand (including cheques/ drafts and imprest)				1,976
3. Bank Balances:				
a) With Scheduled Banks:				
i) In current accounts SBI		5,71,20,097		26,96,235
b) Savings accounts				
i) IOB CS Pur (Non-Plan)	3,77,13,071		1,86,14,872	
ii) IOB CS Pur (Plan)	91,68,749		32,01,028	
iii) UBI CS Pur (Non-Plan)	6,64,385		62,618	
iv) UBI CS Pur (Plan)	22,995		22,229	
v) Project Bank Account	1,13,65,499		90,84,957	
		5,89,34,699		3,09,85,704
TOTAL (A)		**11,88,94,233**		**3,59,70,418**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC. (Contd.)				
B. LOANS, ADVANCES AND OTHER ASSETS				
1. Loans (Interest bearing):				
a) Computer Advance	60,150		1,53,700	
b) Motor Car Advance	-		2,000	
		60,150		1,55,700
2. Interest Accrued but not due on Loans				
a) Motor Car Advance	55,714		-	
b) House Buildings Advance	40,351		52,459	
c) Computer Advance	6,875		5,075	
		1,02,940		57,534
3. Loans (Non-Interest bearing):				
a) Staff Advance	1,22,444		10,754	
b) Travel Advance	1,42,500		2,32,000	
		2,64,944		2,42,754
4. Advances and other amounts recoverable in cash or in kind or for value to be received:				
a) Prepayments	96,061		1,03,497	
b) Security deposit With CESCO	26,21,944		26,21,944	
c) Franking machine deposit	46,273		35,482	
d) Security Deposit with BSNL	2,000		2,000	
e) Security Deposit for GAS	20,950		20,950	
f) STDR against L/C	27,29,833		2,19,97,993	
		55,17,061		2,47,81,866
TOTAL (B)		**59,45,095**		**2,52,37,854**
TOTAL (A + B)		**12,48,39,328**		**6,12,08,272**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 13 - GRANTS/ SUBSIDIES				
1. DAE - Government of India				
a) Non-Plan (Salary)	26,46,00,000		21,70,00,000	
b) Non-Plan (General)	10,22,00,000		8,40,00,000	
		36,68,00,000		30,10,00,000
TOTAL		**36,68,00,000**		**30,10,00,000**

For PARTHA S. MISHRA & CO.
Chartered Accountants
Sanjaya Kumar Patra
CA S.K. Patra (FCA, DISA)
Partner, M. No-301929

22/10/2020
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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 17 - INTEREST EARNED				
1. On Term Deposits:				
a) Others (L/C & Security Deposit)	3,44,007		3,57,238	
		3,44,007		3,57,238
2. On Loans:				
a) Computer Advance	30,940		7,825	
b) House Building Advance	-		60,531	
c) Motor Car Advance	1,39,288		-	
d) Pending Advance	1,342		13,768	
		1,71,570		82,124
TOTAL		**5,15,577**		**4,39,362**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 18 - OTHER INCOME				
1. Miscellaneous Income				
a) Project Overhead	10,53,980		8,69,784	
b) I-Card Charge	454		308	
c) RTI Fee	100		-	
d) Auditorium Charge	73,000		21,500	
e) Unclaimed Deposit W/Off	-		27,960	
f) Miscellaneous Income	8,000		21,298	
		11,35,534		9,40,850
2. Sale of Tender paper		7,000		-
3. Rent				
a) Bank Rent	3,60,000		4,05,000	
b) Guest House Rent	7,17,875		6,24,600	
c) Licence Fee	7,33,920		7,39,855	
		18,11,795		17,69,455
TOTAL		**29,54,329**		**27,10,305**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 20 - ESTABLISHMENT EXPENSES				
1. Salaries and Wages				
a) Staff Salary	10,41,86,862		11,26,66,485	
b) NPS Contribution	42,24,839		30,88,691	
c) Honorarium	8,77,729		14,83,658	
d) Fellowship	2,07,26,858		1,76,63,586	
e) Remuneration to Medical Officer	3,85,000		4,20,000	
		13,04,01,288		13,53,22,420
2. Allowances and Bonus				
a) PRIS	90,59,395		2,84,70,671	
b) Update Allowance	-		26,87,552	
c) Overtime Allowance	15,891		18,641	
		90,75,286		3,11,76,864
3. Staff Welfare Expenses				
a) Reimbursement of Medical Expenses	39,59,291		26,60,774	
b) Recreation & Welfare Expenses	5,01,194		6,61,282	
c) Children Education Allowance	-		18,57,350	
d) Medical Aid Centre Expenses	2,574		20,159	
		44,63,059		51,99,565
4. Retirement and Terminal Benefits				
a) Leave salary	86,11,833		1,07,97,523	
b) Pension	5,34,54,346		3,66,07,848	
c) Gratuity	17,34,515		1,17,18,999	
		6,38,00,694		5,91,24,370
5. Others				
a) Contigency Grant to Scholars		18,36,917		11,44,780
TOTAL		**20,95,77,244**		**23,19,67,999**

22/10/20
कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
भौतिकी संस्थान/Institute of Physics
भुवनेश्वर/Bhubaneswar

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Md. Yunt 22.10.2020
निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES ETC.				
1. MAINTENANCE - a) Civil	1,01,65,656		57,10,500	
b) Vehicle	3,93,910		6,51,978	
c) Library	5,99,376		19,29,855	
d) Workshop	1,19,301		3,84,431	
e) Furniture	2,01,211		74,245	
f) Electrical	12,26,856		5,05,595	
g) AC Plant	44,41,658		42,38,194	
h) Computer	36,22,786		44,38,773	
i) Laboratory	32,23,259		73,90,253	
j) Garden	62,637		1,61,613	
k) Telephone	78,682		4,84,962	
l) Office Equipment	3,85,104		2,28,559	
		2,45,20,436		2,61,98,958
2. Electricity and power		2,14,98,926		2,30,61,011
3. Water charges		3,19,388		3,03,041
4. Conference & Symposia		5,36,263		12,84,122
5. Science Outreach Activities		4,30,571		7,00,208
6. Postage & Telegram		68,220		1,45,878
7. Telephone & Telex		5,58,178		5,70,584
8. Printing and Stationery		9,74,109		9,44,283
9. Travelling Expenses - a) Conference TA	3,54,171		4,66,827	
b) Foreign Travel	4,19,428		5,83,361	
c) Visiting scientist TA	1,87,888		(63,931)	
d) Domestic Travel	15,33,176		16,32,179	
e) Leave Travel concession	6,14,918		9,36,338	
f) Hire Charge	14,428		18,954	
		31,24,009		35,73,728
SUB-TOTAL (A)		**5,20,30,100**		**5,67,81,813**

22/10/20
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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2020

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES Contd....				
10. Auditors Remuneration		-		59,000
11. Entertainment Expenses		2,21,444		2,75,547
12. Security Charges		56,61,545		54,34,108
13. Professional Charges		2,28,620		2,24,612
14. Project Revenue Expenses				
a) ALICE Utilisation and CBM Participation	5,08,035		20,00,494	
b) Development of Computing and Network Facilities	7,97,840		13,37,344	
c) Strengthening Low Energy Accelerator	722		1,50,255	
d) Investigating Spin Structure	-		17,475	
e) Vigyan Pratibha	7,65,271		465	
f) Infrastructure and Housing	6,55,505		40,90,462	
		27,27,373		75,96,495
15. Advertisement and Publicity		6,93,758		16,26,592
16. Books & Journal				
a) Books	4,000		-	
b) Journal	3,38,03,501		-	
		3,38,07,501		
17. Others				
a) Miscellaneous Expenses	1,50,888		1,80,767	
b) JEST Expenses	-		1,63,994	
		1,50,888		3,44,761
SUB-TOTAL (B)		**4,34,91,129**		**1,55,61,115**
GRAND TOTAL (A + B)		**9,55,21,229**		**7,23,42,928**

For PARTHA S. MISHRA & CO.
Chartered Accountants
Sanjaya Kumar Patra
CA S.K. Patra (FCA, DISA)
Partner, M. No-301529

22/10/2020
कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
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BHUBANESWAR

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31.03.2020

SCHEDULE 24 - SIGNIFICANT ACCOUNTING POLICIES

1. **ACCOUNTING CONVENTION**

   The financial statements are prepared and presented on the basis of historical cost convention and on the accrual method of accounting.

2. **INVENTORY VALUATION**

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

3. **INVESTMENT**

   The Institute has no long-term Investment of any nature. However, there are short-term investment in shape of STDR with bank against Letter of Credit.

4. **FIXED ASSETS**

   Fixed Assets are stated at cost of acquisition inclusive of Carriage Inward, duties & taxes and other incidental direct expenses incurred in relation to such particular fixed assets.

5. **DEPRECIATION**

   5.1. 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.

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

6. **BANK BALANCE (Plan – ₹ 6.63 Crore and Non-Plan – ₹ 3.84 Crore)**

   6.1. Plan Included ₹ 4.22 Crore received from DAE under Plan head on 30.12.2019 under Spin Project, the Purchase Order has been issued on 11.03.2020, but L/C couldn't be opened before 31st March 2020 for want of requisite documents from Supplier.

   6.2. Earmarked/ Endowment Fund (As per Sch-3) Bank balances of ₹ 1.14 Crore shown under the total Bank balances

22/10/20

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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 transaction

9. **LEASE**

Out of the total land in possession of the Institute, 6.130 Acres are leasehold and lease rent has been paid upto 31.03.2018. Rest of the land are alienated in favour of the Institute and for this part, no rent is due to the State Government.

10. **RETIREMENT BENEFITS** Liability in respect of Gratuity on retirement payable as on 31.03.2020 has been provided in accounts on actuarial valuation.

10.2. Provision for liability towards accumulated leave encashment benefit to the employees as on 31.03.2020 has been provided for in accounts on actuarial valuation.

10.3. Provision for liability payable towards Pension to employees has not been provided in the Accounts and is accounted on Cash basis.

10.4. No Pension fund has yet been created by the Institute.

10.5. 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.

10.6. The Institute has its own Provident Fund Trust who 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 31.03.2020 has been audited by a firm of Chartered Accountants.

22/10/20
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INSTITUTE OF PHYSICS
BHUBANESWAR

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31.03.2020

SCHEDULE 25 – CONTIGENT LIABILITIES AND NOTES ON ACCOUNTS

1. CONTIGENT LIABILITIES

1.1.	Claims against the Institute not acknowledged as debt	NIL
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 31.03.2020 against 100% margin money	27,29,833/-
1.5.	Disputed demand in respect of	
	Income Tax (TDS) as on 31.03.2020	NIL
	Sales Tax (IDS)	NIL
	Municipal Taxes	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

In the opinion of the Management, 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 except Pension to retired employees have been provided in the accounts of the Institute.

All Unclaimed liabilities for more than 3 years have been taken into Miscellaneous Income.

22/10/20
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2.3. **TAXATION**

Since Institute is a research oriented organization founded by Government of India, Department of Atomic Energy & partly by Government of Odisha and in view there being no taxable income under Income-tax Act 1961, no provision for Income tax has been made during the year.

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

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

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

2.7. Institute has conducted physical verification of Library Books during 2018-19. The shortage of books/ journals in the report has been accounted for in the books of accounts to the extent the Governing Council has accorded its approval.

2.8. STDR Against LC of Rs. 27,29,833/- includes the following:

Date of Payment	Head of A/c	Party Name	Item Name	Amount
14/11/2018	Strengthening Low Energy	Tektronix Asia Ltd	Integrated Resistance measurement	3,70,833
30/10/2019	Strengthening Low Energy	Heidelberg Instrument	Laser based Lithography	23,59,000

2.9. 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.

2.10. Schedule 1 to 25 are annexed to and form an integral part of the Balance Sheet as at 31.03.2020 and Income & Expenditure Account for the year ended on that date.

22/10/20

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2.11. FOREIGN CURRENCY TRANSACTIONS

Value of Imports calculated on C.I.F/Ex-works & FOB basis	31.03.2020 (Rs.)	31.03.2019 (Rs.)
a) Purchase of Lab. Equipments	2,41,06,916	5,32,74,738
b) Stores, Spares and Consumables	6,61,483	43,98,804
c) Journal subscription	2,52,42,903	1,85,35,020
Expenditure in foreign currency		
a) Travel	Nil	Nil
b) Other expenditure (Honorarium)	Nil	57,754
Earnings		
Value of Exports on FOB basis	Nil	Nil
Remuneration to Auditors		
As Auditors	50,000	50,000

For PARTHA S. MISHRA & CO.
Chartered Accountants
Sangaya kumar Patra
CA S.K. Patra (FCA, DISA)
Partner, M. No-301929

22/10/20
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INSTITUTE OF PHYSICS, BHUBANESWAR
STATEMENT OF RECEIPTS & PAYMENTS FOR THE FINANCIAL YEAR 2019-20

(Figure in Rs.)

	RECEIPTS	SCH	Current Year	Previous Year		PAYMENTS	SCH	Current Year	Previous Year
I.	**Opening Balances**				I.	**Expenses**			
	a) Cash in hand		1,976	29,588		a) Establishment Expenses (Corresponding to Sch 20)	C	25,05,33,752	22,15,17,919
	b) Bank balances					b) Administrative Expenses (Corresponding to Sch 21)	D	9,59,65,856	8,12,65,377
	i) In current accounts SBI		26,96,235	59,58,472	II.	**Payments made against funds for various projects**		1,13,94,429	1,26,03,153
	ii) In Savings accounts				III.	**Investments and deposits made**			
	Indian Overseas Bank (NP)		1,86,14,872	1,21,60,145		a) Out of Earmarked/Endowment funds		-	-
	Indian Overseas Bank (Plan)		32,01,028	6,52,29,103		b) Out of Own Funds (Investments-Others)		-	-
	Union Bank (NP)		62,618	17,40,808	IV.	**Expenditure on Fixed Assets & Capital W.I.P**			
	Union Bank (Plan)		22,229	21,468		a) Purchase of Fixed Assets	E	1,00,14,844	8,83,16,431
	Project Bank Account		90,84,957	1,14,84,655		b) Expenditure on Work-in-Progress		-	-
II.	**Grants Received**				V.	**Refund of surplus money/Loans**			
	a) From Govt. of India - Plan		6,00,00,000	3,00,00,000		a) To the Government of India		-	-
	Non-Plan		36,68,00,000	30,10,00,000		b) To the State Government		-	-
	b) From State Government		-	-		c) To other providers of funds		-	-
III.	**Receipt from Sponsored Project**		1,36,74,971	1,02,03,455	VI.	**Finance Charges (Interest)**		-	-
IV.	**Interest Received**				VII.	**Other Payments**			
	a) On Bank deposits		-	-		Project Revenue Expenses	F	27,27,373	72,02,888
	b) Loans, Advances etc.	A	4,70,171	4,62,208		Staff Loan	G	-	1,30,500
V.	**Other Income**				VIII.	**Closing Balance**			
	Misc Receipts		11,35,534	9,12,890		a) Cash in hand		-	1,976
	Sale of Tender paper		7,000	-		b) Bank balances			
	House/Guest House Rent		18,08,195	17,69,455		i) In current accounts SBI		5,71,20,097	26,96,235
	Sale of Asset		-	-		ii) Savings accounts			
VI.	**Amount Borrowed**		-	-		Indian Overseas Bank (NP)		3,77,13,071	1,86,14,872
VII.	**Any Other Receipts**					Indian Overseas Bank (Plan)		91,68,749	32,01,028
	Earnest Money Deposit		(8,84,140)	72,960		Union Bank (NP)		6,64,385	62,618
	Security Deposit		(1,37,009)	1,75,570		Union Bank (Plan)		22,995	22,229
	Caution Money		1,600	3,200		Project Bank Account		1,13,65,499	90,84,957
	Recoveries / Current Dues	B	1,01,30,813	34,96,206					
	TOTAL		**48,66,91,050**	**44,47,20,183**		**TOTAL**		**48,66,91,050**	**44,47,20,183**

For PARITHA S. MISHRA & CO.
Chartered Accountants
Sangaya Kumar Patra
CA S.K. Patra (FCA, DISA)
Partner, M. No-301929

22/10/20
कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2020

(Amount Rs)

	Current Year	Previous Year
SCHEDULE A - INTEREST ON LOANS & ADVANCES		
Interest on House Building Advance	12,108	75,911
Interest on Motor Car Advance	83,574	-
Interest on Motor Cycle Advance	-	4,097
Interest on Computer Advance	29,140	11,194
Interest on Pending Advance	1,342	13,768
Interest on Security Deposit	3,44,007	3,57,238
Total	**4,70,171**	**4,62,208**

22/10/20
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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2020

(Amount Rs)

	Current Year	Previous Year
SCHEDULE B - RECOVERIES & CURRENT DUES		
Advance For Motor Car	2,000	12,000
Advance For House Building	-	4,000
Advance For Computer	93,550	1,16,000
CHSS Contribution Recovery	15,96,582	1,80,979
Deputed Staff Recovery Payable	(32,090)	32,090
Gratuity Payable	1,74,690	2,87,123
GSLI Premium Payable	-	150
Interest Payable to DAE (NP)	38,346	3,66,941
Interest Payable to DAE (Plan)	(5,43,112)	-
IOPEWS Recovery Payable	8,475	-
IPEA Recovery Payable	12,400	-
Non-Plan Recovery Payable	-	3,200
GSLI Claim Payable	14,476	28,223
NPS Recovery Payable	(26,013)	(1,18,436)
Pension Payable	-	(53,266)
Plan Professional Tax Payable	325	-
Plan Security Deposit Payable	36,278	-
Professional Tax Payable	30,650	(725)
Project Grant Payable	(32,33,000)	50,00,000
Provision for Expenses	1,23,38,674	-
GST Recovery Payable	(1,15,999)	40,598
Plan GST Payable	(58,662)	51,450
Plan TDS Payable	(43,190)	(1,903)
Provident Fund Payable	-	(11,262)
TDS Non-Salary Payable	(4,824)	(27,842)
TDS Salary Payable	(69,730)	(24,13,114)
WCT Recovery Payable	(89,013)	-
Total	**1,01,30,813**	**34,96,206**

22/10/20
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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2020

(Amount Rs)

	Current Year	Previous Year
SCHEDULE C - Establishment Expenses		
Salary	11,43,77,765	11,24,69,310
NPS	44,82,436	30,78,502
PRIS	1,85,40,425	1,93,84,081
Update Allowance	23,81,253	22,66,299
Leave Salary	97,83,969	84,73,433
Book Grant & Contigency	18,36,917	11,44,780
Entertainment	2,21,444	2,75,547
Honorarium	9,40,129	14,21,258
Overtime Allowance	15,891	21,495
Children Education Allowance	16,94,250	14,06,610
Pension	5,61,94,065	3,98,42,733
Pre Doctoral Fellowship	44,18,720	42,60,302
Doctoral Fellowship	1,28,61,873	92,88,015
Post Doctoral Fellowship	48,79,530	40,79,804
SSB Award Fellowship	(30,000)	-
Recreation Club Expenses	5,07,424	6,61,282
Reimbursement of Medicine	56,76,468	27,21,158
Remuneration Medical Officer	4,20,000	4,20,000
Medical Aid Centre Expenses	2,574	20,159
Visiting Scientist TA	1,84,288	(63,931)
Leave Travel Concession	6,14,918	7,82,638
Gtatuity	1,05,29,413	95,64,444
Total	**25,05,33,752**	**22,15,17,919**

20/10/20
कनिष्ठ लेखा अधिकारी/Junior Accounts Officer
भौतिकी संस्थान / Institute of Physics
भुवनेश्वर / Bhubaneswar

22/10/2020
रजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

Md. Zuyut 22.10.2020
निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2020

(Amount Rs)

	Current Year	Previous Year
SCHEDULE D - Administrative Expenses		
Administrative		
Advertisement	9,37,591	13,82,759
Audit Fees	59,000	59,000
Conferene & Symposia	5,36,263	12,84,122
Science Outreach activities	4,30,571	6,85,418
Electricity Charges	2,34,87,056	2,30,87,124
Books	4,000	-
Library & Journals	3,38,03,501	1,85,47,936
Miscellaneous Expenses	1,50,888	1,80,767
Postage & Telegraph	85,016	1,26,514
Printing Stationey	9,28,230	9,17,145
Security Services	61,14,412	54,20,150
Foreign Travel Expenses	2,99,428	4,75,361
Domestic Travel Expenses	15,63,676	16,32,179
Confernce TA	3,54,171	4,66,827
Telephone & Telex	6,34,205	5,41,561
Water Charges	3,46,098	3,01,774
Hire Charge	14,428	18,954
JEST Expenses	-	53,994
Professional Charges	2,28,620	2,24,612

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2020

(Amount Rs)

	Current Year	Previous Year
SCHEDULE D - Administrative Expenses (Contd....)		
Maintenance		
Computer Maintenance	41,99,463	41,43,761
Laboratory Maintenance	32,63,259	70,07,327
Civil Maintenance	1,06,50,628	57,12,940
Office Equipment Maintenance	3,95,010	2,39,120
Furniture Maintenance	2,01,211	74,245
Library Maintenance	6,23,376	19,05,855
AC Plant Maintenance	48,02,658	41,94,644
Garden Maintenance	65,157	1,61,613
Electrical Maintenance	12,41,461	11,24,264
Telephone Maintenance	78,682	4,84,962
Workshop Maintenance	59,142	1,52,469
Vehicle Maintenance	4,08,655	6,57,980
Total	**9,59,65,856**	**8,12,65,377**

22/10/20

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SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2020

(Amount Rs)

SCHEDULE E - PURCHASE OF FIXED ASSETS	Current Year	Previous Year
NON-PLAN		
Office Equipment	99,276	6,46,589
Furnitue & Fixtures	27,854	2,83,667
Telephone Equipment	3,850	-
Computer Equipment	33,350	31,090
Workshop Equipment	-	11,200
Electrical Installation	-	20,46,091
Laboratory Equipment	13,54,736	4,23,820
PLAN		
ALICE Utilization and CBM participation	-	7,37,765
Development of Computing & Network Facilities	15,19,754	30,62,754
Strengthening Low Energy Accelerator	69,76,024	4,02,18,880
Study of Growth & Characterization of Advanced Materials	-	3,93,76,268
Investigating Spin Structure	-	14,78,307
Total	**1,00,14,844**	**8,83,16,431**

22/10/20

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2020

(Amount Rs)

	Current Year	Previous Year
SCHEDULE F - PROJECT REVENUE EXPENSES		
PLAN		
ALICE Utilization and CBM participation Expenses	5,08,035	15,62,494
Development of Computing & Network Facilities Expenses	7,97,840	13,37,344
Strengthening Low Energy Accelerator Expenses	722	1,50,255
Study of Growth & Characterization of Advanced Materials Expenses	-	(5,000)
Infrastructure Expenses	6,55,505	41,63,202
Vigyana Pratibha Expenses	7,65,271	465
Investigating Spin Structure Expenses	-	(5,872)
Total	**27,27,373**	**72,02,888**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2020

(Amount Rs)

	Current Year	Previous Year
SCHEDULE G - STAFF LOAN		
Advance For Computer	-	1,30,500
Total	**-**	**1,30,500**

22/10/20

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Md. Yusuf
22.10.2020

DIRECTOR
INSTITUTE OF PHYSICS
BHUBANESWAR

ACTION TAKEN REPORT ON THE COMMENTS OF STATUTORY AUDITOR ON THE ANNUAL ACCOUNTS OF INSTITUTE OF PHYSICS, BHUBANESWAR FOR THE FINANCIAL YEAR 2019-20

Sl. No.	AUDITOR'S OBSERVATION	INSTITUTE'S REPLY
Qualified opinion		
Basis of qualification		
1	IAS 10 regarding to fixed assets and As6 for depreciation have not been followed. There was no fixed asset 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 guide us in this matter. The preliminary report has been received. Due to COVID-19 the assets under dispute could not be physically verified for obtaining the final report of assets as on 31.03.2018.
2	IAS 12 on Accounting of Government grants has not been followed. The grants have been recognized on realization basis. Capital grants are recognized as capital fund and shown as Liability.	The Institute has been receiving full grant from DAE (Govt. of India) under Head of Account Plan and Non-Plan. Plan amount has been shown as Capital Receipt and Non-Plan as Revenue Receipt.
Audit Observation on Accounts		
1	**Maintenance of books of accounts:** The following manual books of accounts are maintained in the year 2019-20 a) Cash cum bank book b) Cheque issue register c) Staff advance register d) Security deposit register e) TDS register	No comment.

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2 **Others:**

a) Advances to staff unadjusted for more than 3 months were found in the following cases. The same should be adjusted /recovered at an earliest.

Sl.	Date	Name	Purpose	Amount(Rs.)
1	29/05/2018	M. M. Mondal	Alice	1,12,000.00
2	29/08/2019	Saroj Kumar Jena	Civil Maintenance	27,000.00
3	26/09/2019	Khirod Chandra Patra	Domestic Travel	30,500.00
4	04/01/2019	D. Topwal (IIT Bombay)	Laboratory Maintenance	10,714.40
5	09/10/2019	D. Topwal (XRD shift)	Laboratory Maintenance	15,000.00
6	19/12/2019	Ghanashyam Pradhan	Postage	20,000.00

b) The STDR against L/C are pending as on 31.03.2020 for more than one (1) month as stipulated by IOP guideline. Some of such instances are given below.

Sl.	Name	Date of Advance	Amount (Rs.)
1	Tektronix Asia Ltd, USA	27.04.2018	3,70,833
2	Heidelberg instruments, Laser based Lithography	30.10.2019	23,59,000

c) During the course of audit, it is noted that GST of Rs.17,479.00 collected in the year 2017-18 is not yet refunded.

a)

1) Travel bill has been submitted by Shri M.M. Mondal, due to lack of documentation it has not been adjusted during 2019-20. However the same has been settled 2020-21.
2) Advance to Shri S. Jena has been adjusted on 09.05.2020.
3) Outstanding advance has been settled in 2020-21
4) Outstanding advance has been settled in 2020-21
5) Outstanding advance has been settled in 2020-21
6) Advance to Shri G. Pradhan has been adjusted on 06.05.2020.

b) The L/C are opened and settled as per term of the Purchase Order. During the year 2020-21, these outstanding L/C have been settled.

d) It was deducted as GST TDS The same has been settled in 2020-21.

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