Annual Report

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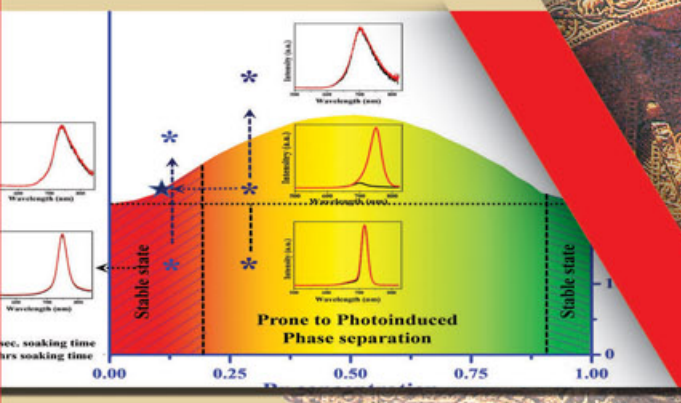
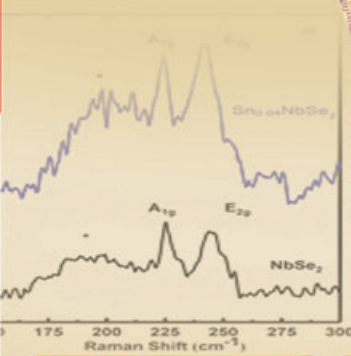
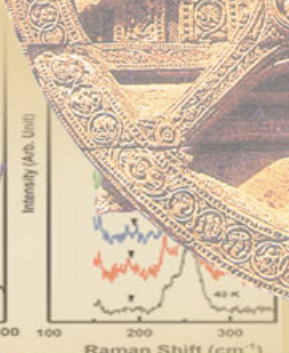
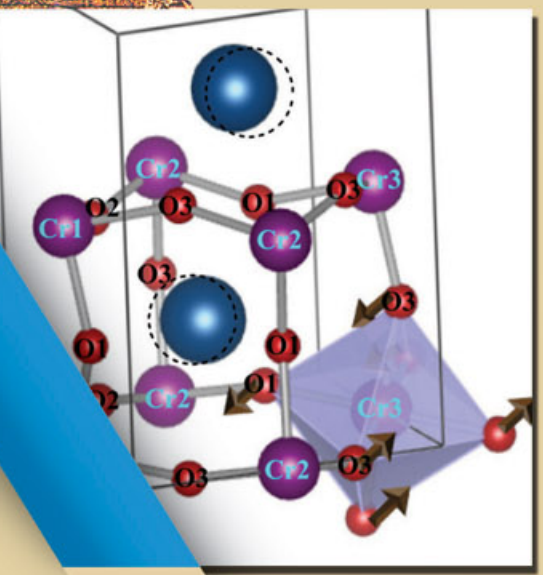
Audited Statement of Accounts

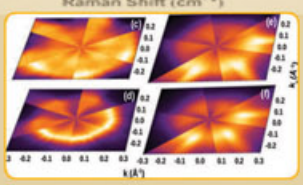
2018-19

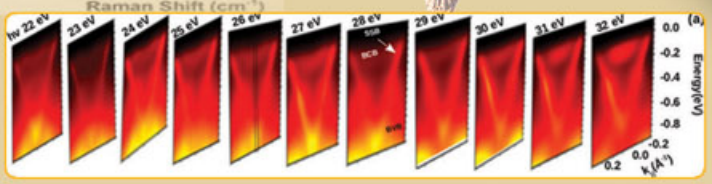












Institute of Physics

Bhubaneswar

Annual Report

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2018-19

Institute of Physics

Bhubaneswar

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Contents

About the Institute

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

The Institute has a vibrant research programme in the fields of theoretical and experimental condensed matter physics, theoretical high energy physics and string theory, theoretical nuclear physics, ultra-relativistic heavy-ion collisions and cosmology, quantum information and experimental high energy nuclear physics. The 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 Institute campus has housing facilities for the employees and hostels for the scholars and post-doctoral fellows. Compact efficiency apartments are available for post-doctoral fellows and visitors. Both indoor and outdoor games and sports facilities are also available in the campus. The Institute has a Mini-Gym in the New Hostel. The Institute also has a guest house, auditorium, and dispensary in the campus.

The Foundation Day of the Institute is celebrated on 4th of September every year.

CHAIRMAN AND MEMBERS OF THE GOVERNING COUNCIL OF INSTITUTE OF PHYSICS, BHUBANESWAR FOR THE ANNUAL REPORT FOR THE YEAR 2018-19

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Prof. Sudhakar Panda, Director, National Institute of Science Education and Research, P.O. Sainik School, Bhubaneswar-751005.	:	Member
Prof. Pinaki Majumdar, Director Harish-Chandra Research Institute, Chhatnag Road, Jhunsi, Allahabad-211019.	:	Member
Prof. Ajit Kumar Mohanty, Director, Saha Institute of Nuclear Physics, Sector-1, Block-A/F, Bidhan Nagar, Kolkata-700064.(up to 29.03.2019)	:	Member
Prof. Gautam Bhattacharyya, Director, Saha Institute of Nuclear Physics Sector-1, Block-A/F, Bidhan Nagar, Kolkata-700064. (From 29.03.2019)	:	Member
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Prof. Saroj Kumar Nayak, School of Basic Sciences, Indian Institute of Technology, Bhubaneswar-751013.	:	Member
Prof. Sukanta Kumar Tripathy, P. G. Department of Physics, Berhampur University, Bhanja Vihar, Ganjam-760007	:	Member
Prof. Sudhakar Panda, Director, Institute of Physics, Bhubaneswar-751005	:	Member

Secretary to the Governing Council

Shri R. K. Rath
Registrar, Institute of Physics,
Bhubaneswar - 751005

From the Director's Desk

I am delighted to present the Annual Report of Institute of Physics (IOP), Bhubaneswar for the year 2018-19. This Annual Report reflects our various academic, research activities and accomplishments. IOP is an autonomous Institute under the umbrella of Department of Atomic Energy, Government of India. It is one of the premier research institutions in India perusing high quality and advanced research in the areas of both experimental and theoretical Physics.

During this year, excellent research work on both fundamental and applied physics have been carried out by the members of IOP and this has resulted in about 132 publications in the International Peer-Reviewed Journals. Different scientific activities such as regular seminars, colloquium and workshops were organized. The purpose of these activities is to seek opportunities for collaboration between IOP and other national and international institutes on emerging areas in physics. This year 23 eminent scientists of national and international repute have been invited to deliver colloquium and popular talks.

One of the motto of IOP is to disseminate the awareness of Science and elevate scientific temper among young school and college programs via conducting the National Science Day celebration, student visit program etc. In the coming days, let's all stand ready and work together with renewed intensity and vigor in taking the Institute to greater height.

I take this opportunity to acknowledge and appreciate the support and encouragement received from all the stake holders associated with IOP including the Governing Council. I also express my gratitude to those who have contributed their time and energy to give shape to this Annual Report in the current form.

Professor Sudhakar Panda
FASc, FNA, FNASc, J.C.Bose Fellow
Director, IOP, Bhubaneswar

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 IOP Annual Report 2018-19

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. A recent study has been performed, analyzing data from the IceCube Neutrino Observatory at the South Pole, looking for changes in neutrino oscillation behavior caused by long-range interactions from large collections of electrons (selected as PRL Editors' Suggestion). 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.

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, strongly correlated systems etc. During last year, with the help of theoretical modeling and experimental collaboration, the group members have investigated a macro-molecular crowding mediated mechanism of the formation of bacterial nucleoid, its helicoid morphology, central positioning and precise segregation in growing E.coli cells, new transport signature of Majorana fermions via the spin-selective coupling to the ferromagnetic boundary, magnetic exchange properties of anisotropic Dirac materials, 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. A major contribution has been made to the recent observation of the Higgs boson production in association with a pair of top quarks by the CMS experiment at LHC, which is the heaviest fermion known till date (published in PRL). 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. Commonly used ion beams are that of H, He, C, N, Si, Mn, Ag and Au. After the recent upgradation of low energy 3MV accelerator of IOP, there is a significant increase in the number of users (both internal and external). During this period the accelerator facility has catered several users from University College of Engineering, Vishakhapatnam, OUAT-Bhubaneswar, Indraprastha University-New Delhi, SOA University-Bhubaneswar, BARC-Mumbai, 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.

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, 2018 and ended in July, 2019. 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.

A total of 339 students were called for written test and interview for admission to the predoctoral course in July, 2018. This includes JEST qualifiers, UGC-CSIR qualifiers and valid GATE score holders. Following students successfully completed the doctoral course work in July, 2019:

1. Mr. Abhishek Roy
2. Ms. Aisha Khatun
3. Mr. Ankit Kumar
4. Mr. Arnob Kumar Ghosh
5. Mr. Arpan Sinha
6. Mr. Chitrak Karan
7. Mr. Harish Chandra Das
8. Mr. Mousam Charan Sahu
9. Mr.PragyanprasuSwain
10. Mr.Pritam Chatterjee
11. Mr.Ritam Kundu
12. Mr.Sachin Chauhan
13. Mr. Sameer Kumar Mallik
14. Ms. Sandhyarani Sahoo
15. Mr. Siddharth Prasad Maharathy
16. Mr. Sudipta Das

Mr. Chitrak Karan was adjudged as the most outstanding scholar and was awarded the L. K. Panda Memorial Fellowshipfor the year 2018-19.

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

Semester – I

Advanced Quantum Mechanics	:	Dr. S. Banerjee
Advanced Statistical Mechanics	:	Prof. S.M Bhattacharjee
Quantum Field Theory – I	:	Dr. Debottam Das
Many Body Physics	:	Dr. Arijit Saha
Advanced Experimental Techniques	:	Dr. Debakanta Samal
Experimental Physics	:	Dr. Dinesh Topwal

Semester – II

Numerical Methods Mathematical Methods and Research Methodology	:	Dr. Arun K. Nayak
Advanced Condensed Matter Physics	:	Dr. Saptarshi Mandal
Active Matter Physics	:	Dr. Debasish Chaudhuri
Quantum Field Theory – II	:	Dr. Manimala Mitra
High Energy Physics	:	Dr. Sanjib Kumar Agarwalla
Critical Phenomena	:	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 2018-2019 are given below along with the name of the supervisor.

Name of Supervisor	Name of Student	Title of Project
Dr. Manimala Mitra	Mr. Abhishek Roy	The real gauge Singlet extension of Standard Model: A possible candidate of cold dark matter
Dr. Arijit Saha	Ms. Aisha Khatun	Majorana Zero Modes (Topological Superconductivity) in helicalShiba Chains
Prof. Suresh Patra	Mr. Ankit Kumar	Relativistic Mean Field Theory
Dr. Arijit Saha	Mr. Arnob Kumar Ghosh	Higher Order Topological Insulator
Dr. Debasish Chaudhuri	Mr. Arpan Sinha	"Study of Active Brownian Particles"
Dr. Debasish Chaudhuri	Mr. Chitrak Karan	Statistical Analysis of Active Loop Extrusion Process"
Dr. Aruna Nayak	Mr. Harish Chandra Das	"Understanding of Quark and Gluon Jet Structure"
Dr. Satyaprakash Sahoo	MousamCharan Sahu	Raman Spectroscopy of Graphene and characterization of Graphene field effect transistor"
Dr. Sanjib Kumar Agarwalla	Mr.Pragyanprasu Swain	"Exploration of neutrino properties with an emphasis on measurement of CP violation in oscillation experiments"
Dr. Arijit Saha	Mr.Pritam Chatterjee	"Weyl Superconductor"
Dr. Saptarshi Mandal	Mr.Ritam Kundu	"Calculation of Reduced Density Matrix from Correlation Functions in Condensed Matter System"
Dr. Shamik Banerjee	Mr.Sachin Chauhan	"Elements of Conformal Field Theory"
Dr. Satyaprakash Sahoo	Mr. Sameer Kumar Mallik	"Raman Study of defect induced vibrational modes in few layer MoS2"
Dr. Satyaprakash Sahoo	Ms. Sandhyarani Sahoo	Thermal conductivity of isolated silicon nanowire by Raman spectroscopy"
Dr. Manimala Mitra	Mr. Siddharth Prasad Maharathy	"See-Saw mechanism and Neutrino Mass Generation"
Dr. Sanjib Kumar Agarwalla.	Mr. Sudipta Das	Importance of matter effect in three flavor neutrino oscillation.

1.2 DOCTORAL PROGRAM

Presently Institute has thirty sevendoctoral scholars working in different areas under the supervision of its faculty members. All the scholars are registered with HomiBhabha 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 HomiBhabha National Institute on the basis of thesis submitted / *defended.

1. **Mr. Priyo Shankar Pal**

   Advisor : Prof. Arun M Jayannavar

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

2. **Mr. Ranveer Singh**

   Advisor : Prof. T. Som

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

3. **Mr. Sumit Nandi**

   Advisor : Prof. Pankaj Agrawal

   Thesis Title: *"Quantum Information Processing Protocols and Entanglement"*

4. **Mr. Soumyabrata Chakraborty**

   Advisor : Prof. Sudipta Mukherji

   Thesis Title : *"Field Theory on Cosmological Spacetime: Some Results from Ads/CFT"*

5. **Mr. Subhadip Ghosh**

   Advisor : Dr. Goutam Tripathy, Co-guide- Dr. Debasish Chaudhuri.

   Thesis Title: *"Active Maintenance of Structure and Transport: Impact of Molecular."*

6. **Mr. Arpan Das**

   Advisor : Prof. Ajit M. Srivastava

   Thesis Title: *"Consequences of phase transition dynamics in neutron stars".*

7. **Ms. Sudipta Mahana**

   Advisor : Dr. Dinesh Topwal

   Thesis Title : *"Magnetic and Ferroelectric Properties of Some Advanced Functional Oxides and Related Phenomena."*

8. **Shri Sabyasachi Chaterjee**

   Advisor : Dr. Sanjib K. Agarwalla

   Thesis Title : *"Exploring Light Sterile Neutrinos and Long-Range Forces in Long-Baseline Experiments."*

9. **Puspendu Guha**

   Advisor : Prof. P. V. Satyam

   Thesis Title : *"Silver Nanostructures on Oxide Surfaces: Growth, Characterizations* and Applications."

10. **Mr. Bharat Kumar**

    Advisor: Prof. Suresh Kumar Patra

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

11. Mr. Chandan Datta

Advisor : Prof. Pankaj Agarwal

Thesis Title: *"Quantification and Characterization of Entanglement and Coherence"*

12. **Mr. Shreyansh Dave**

Advisor : Prof.Ajit M. Srivastava

Thesis Title: *"Superfluid Transition, Topological Vortices, and Magneto-hydrodynamic Simulations for Relativistic Heavy-ion collisions"*

1.4 Summer Student's 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 22ndMay to 15thJuly, 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*
Bhagyarathi Sahoo	*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*
Kamalakanta Juadi	*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.Manimala Mitra*

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.

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

1. Resistive Magneto hydrodynamics Simulations in relativistic heavy- ion collisions

We are setting up code for resistive magneto hydrodynamics simulations in for heavy-ion collisions. This will allow us to extend our earlier investigations to realistic estimates of trapping of magnetic field in the plasma during initial stages.

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

2. Magneto hydrodynamics Simulation of deformed nucleus collision and quadrupole magnetic field at fermi scale

We are studying special crossed configurations of uranium-uranium collisions in heavy-ion collisions to study the nature of resulting magnetic field. We find that it leads to quadrupolar field at the scale of fermi. We are investigating its beam-focusing effects in terms of non-trivial rapidity dependence of radial flow, specifically in violation of Bjorken boost invariance.

(M. Biswal, S.S. Dave, P.S. Saumia and A. M. Srivasta)

3. Continuing project: Adiabaticity violation and Quarkonia Disintegration due to spatial and temporal fluctuations in in Relativistic Heavy Ion Collisions

We study adiabaticity violation of J/ψ evolution due to spatial and temporal variations of energy density in relativistic heavy-ion collisions by calculating the survival probability of J/ψ and Y using time dependent perturbation theory.

(P. Bagchi, N. Dutta, and A. M. Srivastava)

4. Analogue gravity in heavy-ion collisions, black hole and Hawking radiation in relativistic heavy-ion collisions

Unruh had proposed analogue gravity models wherein a fluid flow can represent a black hole horizon at the point where flow becomes supersonic. This leads to the prediction of Hawking radiation effects in hydrodynamical models of quantum fluids. We apply these ideas to rapidly expanding QGP in relativistic heavy-ion collisions and investigate the effects of resulting Hawking radiation of particle momentum distributions. We carry out UrQMD simulations to determine suitable collision energy for which a stationary event horizon can be achieved in heavy-ion collisions. We are also studying the case of dynamical horizon and resulting Hawking radiation.

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

5. Cosmology and astrophysics Pulsars as Weber gravitational wave detectors

We show that pulsars can act as gravitational wave detectors. The basic physics of our model is based on the fact that a gravitational wave passing through a pulsar will lead to a variation in the moment of inertia of the pulsar affecting its rotation. This will affect the extremely accurately measured spin rate of the pulsar as well as its pulse profile (due to induced wobbling depending on the source direction). The effect will be most pronounced at resonance and should be detectable by accurate observations of the pulsar signal. The pulsar, in this sense, acts as a remotely stationed Weber detector of gravitational waves whose signal can be monitored on earth.

(Arpan Das, Shreyansh S. Dave, Oindrila Ganguly, Ajit M. Srivastava)

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. An important implication of this result is that it allows us to revisit the already detected GW events via pulsars. This allows the possibility of further information about the gravitational source, along with the information of pulsar interior, and can also help in better triangulation of the source location. Importantly, pulsars may allow us to detect those events whose direct signal reached earth in past, hence was missed. In this work we consider two specific GW events GW170817 and GW170814 and list specific pulsars whose signals will carry the imprints of these events in future, to be specific we constrain it within 100 years. Interestingly one specific pulsar J0437-4715 is expected to carry the imprints of the event GW170814 on 1st May 2035 (with timing error of about 2 months). Other GW events need to be analyzed to see if some pulsar can relay the perturbed signal reaching earth at an even earlier date.

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

7. 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)

8. Shape of the Higgs Potential at Future Colliders

Although Higgs boson has been discovered, but its self-couplings are poorly con- strained. This leaves the nature of Higgs potential largely undetermined. If the Higgs boson is a pseudo Goldstone boson or a pseudo dilaton, its Higgs potential could be quite different from the Landau-Ginzburg type potential. We systematically organize typical new physics scenarios according to structure of Higgs self-couplings, and utilize the processes pp $\rightarrow$ HH and pp $\rightarrow$ HHH to determine the Higgs trilinear and quartic couplings. Although it is hard to measure the Higgs trilinear coupling at HL-LHC with high precision, we could determine its value precisely at 27 TeV HE-LHC and thus have ability to discriminate different Higgs scenarios. To fully determine shape of the Higgs potential, it is necessary to probe the quartic Higgs coupling through the pp $\rightarrow$ HHH process at 100 TeV collider. For each scenario, we give the possible bounds on the quartic Higgs coupling based on the precision of the measurement of the cross section.

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

9. Cosmology and AdS/CFT:

Choosing appropriate matter stress tensor, AdS dual of a four-dimensional radiation dominated universe can be constructed. This set up then allows us to explore properties of a strongly coupled field theory on radiation dominated universe. With S. Mishra, Y. Srivastava, we are computing various two-point correlators in this time dependent background using the bulk-boundary correspondence.

(S. Mukherji)

10. Neutrino Probes of Long-Range Interactions

Astrophysical searches for new long-range interactions complement collider searches for new short-range interactions. Conveniently, neutrino flavor oscillations are keenly sensitive to the existence of long-ranged flavored interactions between neutrinos and electrons, motivated by lepton-number symmetries of the Standard Model. For the first time, we probe them using TeV–PeV astrophysical neutrinos and accounting for all large electron repositories in the local and distant Universe. The high energies and colossal number of electrons grant us unprecedented sensitivity to the new interaction, even if it is extraordinarily feeble. Based on Ice Cube results for the flavor composition of astrophysical neutrinos, we set the ultimate bounds on long-range neutrino flavored interactions. Recently, this paper has been published in Phys. Rev. Lett. 122 (2019) no.6, 061103 [reference 1 in the publication list]. It has been also selected as PRL Editors' Suggestion and has been featured in APS Physics.

(M. Bustamante, S. K. Agarwalla)

11. Active-sterile neutrino oscillations at INO-ICAL over a wide mass-squared range

We perform a detailed analysis for the prospects of detecting active-sterile oscillations involving a light sterile neutrino, over a large Δm^2_{41} range of ~10^{-5} eV^2 to 10^2 eV^2 using 10 years of atmospheric neutrino data expected from the proposed 50 kt magnetized ICAL detector at the INO. This detector can observe the atmospheric ν_μ and $\bar{\nu}_\mu$ separately over a wide range of energies and baselines, making it sensitive to the magnitude and sign of Δm^2_{41} over a large range. If there is no light sterile neutrino, ICAL can place competitive upper limit on $|U_{\mu 4}|^2 \leq 0.02$ at 90% C.L. for Δm^2_{41} in the range (0.5-5) × 10^{-3} eV^2. For the same $|\Delta m^2_{41}|$ range, ICAL would be able to determine its sign, exploiting the Earth's matter effect in μ^- and μ^+ events separately if there is indeed a light sterile neutrino in Nature. This would help identify the neutrino mass ordering in the four-neutrino mixing scenario.

(T. Thakore, M.M. Devi, S. K. Agarwalla, A. Dighe)

12. Signatures of a Light Sterile Neutrino in Tokai to Hyper-Kamiokande Experiment

We investigate the performance of upcoming Tokai to Hyper-Kamiokande longbaseline neutrino oscillation experiment in the presence of a light eV scale sterile neutrino. We study in detail its influence in resolving fundamental issues like mass hierarchy, CP-violation (CPV) induced by the standard CP-phase δ_{13} and new CP-phase δ_{14} and the octant ambiguity of θ_{23}. We show for the first time in detail that due to the impressive energy reconstruction capabilities of T2HK, the available spectral information plays

an important role to enhance the mass hierarchy discovery reaches of this experiment in 3ν framework and also to keep it almost intact even in 4ν scheme. This feature is also of the utmost importance in establishing the CPV due to δ_{14}. As far as the sensitivity to CPV due to δ_{13} is concerned, it does not change much going from 3ν to 4ν case. We also examine the reconstruction capability of the two phases δ_{13} and δ_{14} and find that the typical 1σ uncertainty on δ_{13} (δ_{14}) in T2HK is $\sim 15^0$ (30^0). While determining the octant of θ_{23}, we face a complete loss of sensitivity for unfavorable combinations of unknown δ_{13} and δ_{14}.

(S. K. Agarwalla, S.S. Chatterjee, A. Palazzo)

13. Flat space holography and it's relation to S-matrix.

My current research interest is in soft theorems, asymptotic symmetries in flat space and S matrix theory. Some years ago, Strominger has proved that soft theorems in quantum field theory are equivalent to Ward identities for infinite dimensional asymptotic symmetries in flat space which can act on the S-matrix elements. For example, Weinberg's soft graviton theorem is equivalent to the Ward identity for BMS symmetries. Now the statement that the S-matrix elements transform under infinite dimensional global symmetries is potentially very powerful. In recent works we have used this to address the question whether any theory whose S-matrix elements satisfy the Ward identity for BMS symmetries must have a massless spin-2 particle or graviton. It turns out that the answer is yes if we make certain reasonable assumptions about the nature of the asymptotic symmetries. Quite surprisingly the methods of conformal field theory play a central role in this proof. The main motivation behind these works is to understand the concept of flat space holography better. There are many formulations of flat space holography but the recent understanding of asymptotic symmetries and its relation to S-matrix seems to be very deep.

(S. Banerjee)

14. Dominant production of heavier Higgs bosons through vector boson fusion in NMSSM:

We study the features of the additional Higgs bosons in the Next-to-Minimal Super symmetric Standard Model where the lightest beyond Standard Model Higgs boson does not dominantly couple to up-type quarks. The new state is dominantly singlet-like while it can also accommodate a small down-type Higgs component. The gluon-gluon fusion cannot be adequate enough for such a Higgs production. We show that the vector-boson fusion may become the leading production mechanism to probe this new scalar at the LHC. Using the existing 13 TeV LHC data for an integrated luminosity 36.1 f b^{-1}, we show the LHC constraints on the parameter space. Finally, we also study the reach of the planned high luminosity LHC ($\mathcal{L}$ = 3 ab^{-1} at $\sqrt{s}$ = 14 TeV) and the proposed high energy upgrade of the LHC ($\mathcal{L}$ = 15 ab^{-1} at $\sqrt{s}$ = 27 TeV) to probe this singlet-like Higgsscalar.

(D. Das)

15. Phenomenology of Non-Holomorphic SUSY breaking in MSSM

In this work, we would retain ourselves within the MSSM field content augmented with most general soft SUSY breaking terms without going down or its High energy origin. In most of

the studies MSSM usually includes only holomorphic soft SUSY breaking terms. However, in a most generic framework, it has been shown that certain non-holomorphic (NH) supersymmetry breaking terms may qualify as soft terms in absence of any gauge singlet fields. Such a consideration is not purely academic, instead one may find a few benefits, like, one may find that lightest CP even Higgs mass can be achieved with lighter squarks with the help of the specific A'_t, A'_b. Similarly, the NH terms may also be helpful to fulfill constraints from rare B-decays (viz. Br ($B \rightarrow X_s+\gamma$), Br ($B_s \rightarrow \mu^+\mu^-$ etc.) both in pMSSM like scenario or in some high scale model like CMSSM or mGMSB which has been shown by us recently. Another interesting feature is that a small NH trilinear coupling (namely A'_μ) may be capable to attune the inflexible constraints of $(g - 2)_\mu$. Concentrating on the leptonic sector only, the playground associated with the NH soft terms is not completely free, rather there can be strong constraints appearing from different charged lepton flavor violating decays (cLFV) via their off-diagonal entries similar to holomorphic trilinear couplings in pure MSSM. We will consider the slepton mass squared matrix to be diagonal, and the only source of cLFV are A_f & A'_f. For the sake of explicit understanding we will scan either A_f & A'_f or A′ at a time to find the allowance of the off-diagonal elements of A_f or A'_f under present and future experimental sensitivities of different cLFV observables. In order to perform this analysis, a more important checkpoint is dangerous charge and color breaking global minima (CCB). It is known that a large trilinear coupling, be it only a diagonal one or a non-diagonal together with diagonal ones leads to unphysical or metastable CCB minimal. For lepton flavor it is only charge breaking (CB). Similarly, NH soft SUSY breaking terms in the Minimal Supersymmetric Standard Model (MSSM) can lead to significant enhancement of the Higgs decays to flavour violating final states. We have been studying the phenomenology of Non-holomorphic (NH) soft SUSY breaking terms in the context of different flavour violating processes in MSSM framework.

(Utpal Chattopadhyay, D. Das, Samadrita Mukherjee)

16. Dirac Seesaw and Dark matter

We have been trying to propose a new mechanism for neutrino mass generation assuming neutrino as the Dirac particle. The neutrinos may receive masses radiatively through the presence of other gauge-singlet neutral states in the loops. This simple model can explain the observed dark matter density of the Universe. Similarly, one may find significant enhancement in the charged lepton flavor violating (cLFV) process like $\mu \rightarrow e\gamma$ or $\mu \rightarrow 3^e$ etc. We have found a co-relation between the cLFV branching ratios and the dark matter relic density which may be probed at the future experiments.

(D. Das, Bibhabasu De, Manimala Mitra, Nirakar Sahoo)

17. LHC phenomenology of Gravitino LSP

The electro-weak sectors in the MSSM are less constrained at the LHC compared to the strongly interacting sectors. The situation can be further improved if gravitino can be considered as the lightest SUSY particle (LSP). The gravitino was the first supersymmetric Dark Matter (DM) candidate and is still one of the best motivated candidates. In some of the supersymmetry

breaking schemes, such a state may appear naturally as the lightest supersymmetric particle. The dark matter phenomenology of the gravitino LSP has been well-studied in the past few years. In this work, we have been studying the LHC phenomenology of the gravitino LSP in the general MSSM assuming that strongly interacting particles are beyond the reach of the LHC.

(Manimala Chakroborty, Arghya Chowdhury, D. Das, Bibhabasu De, Sujoy Poddar)

18. Dark matter through Torsion portal and its phenomenology

In this work we consider different kinds of extensions of the SM of gravitational origin. In particular, we consider space-time torsion which can couple to SM fermions. An advantage of this kind of extension is that it follows from the unification of matter fields with gravity, like what happens in the framework of (super) string theory. It is known that superstring theory predicts the existence of torsion with a non-minimal coupling to scalar fields and fermions. As a result, the compactification of extra dimensions can in general give rise to a theory with a modified form of such non-minimal couplings in the low-energy limit. On the phenomenology side, torsion can act as the dark matter portal to satisfy the observed dark matter density.

(Tapobroto Bhanja, D. Das, Debaprasad Maity)

19. Flat jet signature of heavy neutrino in collider and a right-handed neutrino from leptoquark

During April 1st, 2018 and March 31st, 2019, seven publications and preprints have been made,This also includes, The CLIC Potential for New Physics, arXiv:1812.02093, CERN Yellow Rep.Monogr. Vol. 3 (2018). This discuss in detail the physics potential of future e+e- collider, that can operate at a higher c.m.energy.

In the recent works, arXiv: 1810.08970, we have looked into detail the fat-jet signature of a heavy neutrino at an e+e- collider. This is the first study of these kinds, where, the authors have looked into fat jet signature at a lepton collider. In other works, such as, arXiv: 1903.0143, we have looked into the Higgs triplet model in great detail. We have explicitly analysed the signature of a doubly charged Higgs in a future e- p collider. In other publications, such as, Phys.Rev. D98 (2018) no.9, 095004, we have looked into a different production mechanism of a right-handed neutrino from leptoquark. Another example of an alternate left right symmetric model is Phys.Rev. D98 (2018) no.11, 115038, arXiv: 1805.09844, where, the model requires the presence of MeV to KeV scale right handed neutrino. Most of the above works focused on seesaw signatures of a right-handed neutrino or Higgs triplet. The analysis has been carried out with great details. Realistic estimates have been made in predicting new signals.

(M. Mitra)

20. Universal Extra Dimension models with gravity mediated decays after LHC Run II data

In the 'fat-brane' realization of Universal Extra Dimension (UED) models, the gravity mediated decays of Kaluza-Klein (KK) excitations of the Standard Model (SM) particles offer interesting collider signals. Colored level-1 KK-particles (quarks q1 and/or gluons g1) are pair-

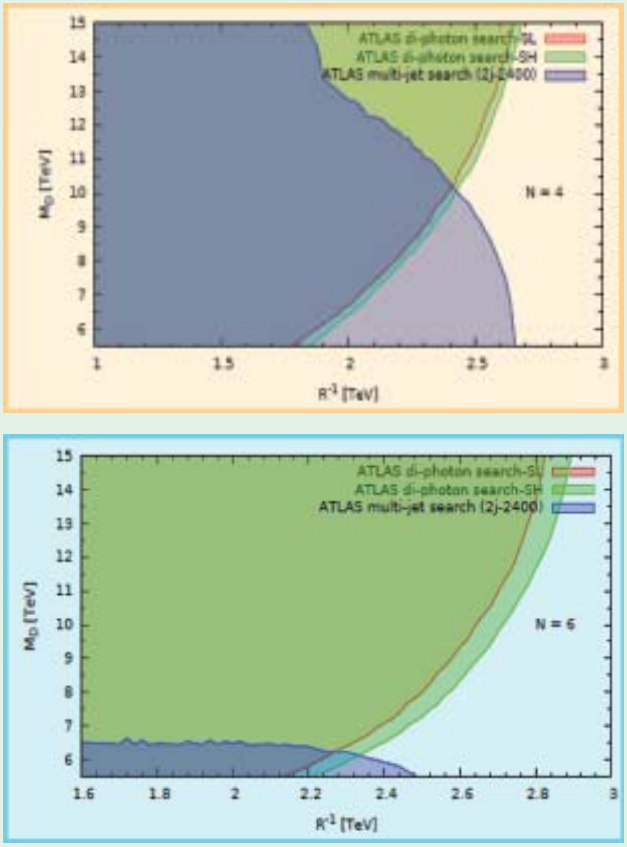


Fig.-1. The exclusion region of 'fat-brane' UED model parameters R^{-1} and M_D from ATLAS multi-jet (green (and blue for N = 6)) and di-photon (red) searches for $N = 4$ and 6. $\Lambda R = 5$ is assumed throughout the analysis.

produced at the colliders due to conserved KK-parity. These particles, then, cascade decay into lighter level-1 KK-particle in association with one or more SM particles until producing lightest KK particle (LKP). The gravity mediation allows LKP to decay into photon or Z-boson plus gravity excitation, hence resulting in di-photon /Z Z/Zγ plus missing transverse energy signatures at collider experiments. Alternatively, pair-produced Level-1 KK quarks/gluons may directly decay into the corresponding SM quark/gluon and a gravity excitation resulting in di-jet plus missing transverse energy signal. We constrain the 'fat-brane' UED model parameters, namely the fundamental Planck mass and M_D the size of small extra dimensions R, in the light of ATLAS searches.

(K. Ghosh, D. Karabacak and S. Nandi)

21. Same-sign multilepton signatures of an $SU(2)_R$ quintuplet at the LHC

We study in detail the collider signatures of an $SU(2)_R$ fermionic quintuplet in the framework of left-right symmetric model in the context of the 13 TeV LHC. Apart from giving a viable dark matter candidate (x^0), this model provides unique collider imprints in the form of same-sign multileptons through the decays of multi-charged components of the quintuplet. In this paper, we mainly focus on the same-sign n-lepton signatures (nSSL). We show that with an integrated luminosity of 500^{fb-1}, the mass of the

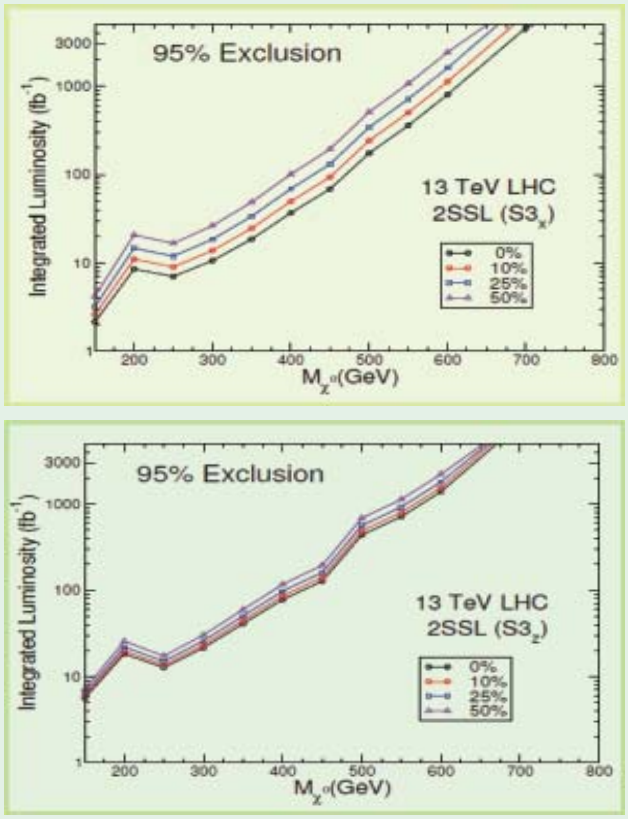


Fig.-2. The required integrated luminosity for 95% CL exclusion as a function of quintuplet mass. See JHEP 1901, 080 (2019) for details.

neutral component, $M_{\chi^0} \leq 480(800)$ GeV can be excluded at 95% CL in the 2SSL (3SSL) channel after imposing several selection criteria.

(*K. Ghosh and collaborators*)

22. Probing nonstandard neutrino interactions at the LHC Run II

Searching for non-standard neutrino interactions, as a means for discovering physics beyond the Standard Model, has been one of the key goals of dedicated neutrino experiments, current and future. The dimension-6 neutrino-quark interactions can be expressed in terms of the chirality projection operators PX (X = L;R), as

$$\mathcal{L}_4 = -2\sqrt{2}G_F\epsilon^{qX}_{\alpha\beta}\left(\bar{q}\gamma_\mu P_X q\right)\left(\bar{\nu}_\alpha\gamma^\mu P_L \nu_\beta\right) + H.C.,$$

where α, β denote the neutrino flavours, q is a quark field, and $\epsilon^{qX}_{\alpha\beta}$ are arbitrary constants, presumably $\lesssim O(10^{-2})$. We demonstrate here that much of the parameter space accessible to such dedicated neutrino experiments is already ruled out by the RUN II data of the Large Hadron Collider experiment.

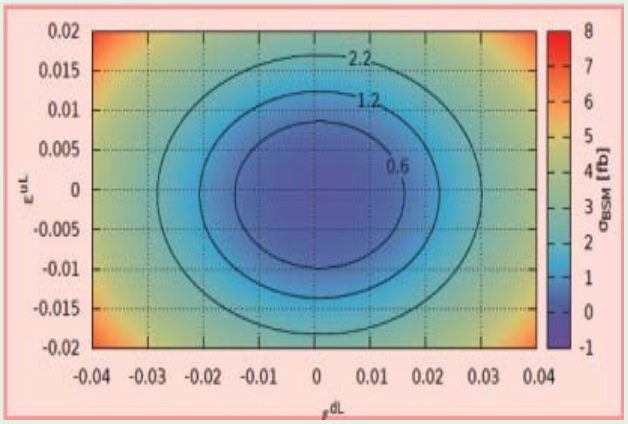


Fig.-3. NSI contributions (shown by color gradient) to the ATLAS search regions for Monojet + $\not{p}_T$ signature in SR-IM9 as a function of $\in^{uL}$ and $\in^{dl}$.

(D. Choudhury, K. Ghosh and S. Niyogi)

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

Electron scattering methods, involving nucleus which have little or no intrinsic deformation suggest nucleon distribution to be of Fermi type. This distribution is further parameterized as Wood Saxon (WS) distribution, where a uniform charge density with smoothed-out surface have been implemented. Incorporating shape modification in WS, earlier attempts were made to explain observables in deformed nuclear collisions, such as charged particle multiplicity. In this work, we use an alternate approach known as Nilsson model or Modified Harmonic Oscillator (MHO), to explain charged particle multiplicity in U+U collisions at top RHIC energy. We have implemented the formalism in HIJING model and we found that the model describes the experimental data to an extent.

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

2. Enhanced production of multi-strange hadrons in proton-proton collisions

Strangeness enhancement is proposed as a signature of QGP formation in nuclear collisions. ALICE has published [1] that in pp collisions at 7 TeV, the pT integrated yields of strange and multi-strange particles relative to π increase significantly with multiplicity. The observed enhancement increases with the strangeness content but not with the mass and baryon number of the hadron. To understand this behavior, we have studied on the simulation models. We have found, the models EPOS and AMPT are not able to explain simultaneously the effect of strangeness canonical suppression in low multiplicity events and QGP like effect in high multiplicity pp collisions at LHC energies.

(S. Sahoo, P. K. Sahu and M. K. Parida)

3. Temperature dependence of symmetry energy and its volume and surface contributions in some rare earth nuclei:

Symmetry energy, characterizing the neutron-proton imbalance in nuclei, is one of the key issues of contemporary nuclear physics. It plays a pivotal role in wider domain of nuclear phenomena extending from the study of structure of nuclei, dynamics of asymmetric heavy ion reactions to the neutron stars. Here, we have analyzed the influence of temperature on the nuclear symmetry energy (NSE) and its volume and surface components in the isotopic series of rare earth Nd, Sm, Gd and Dy nuclei with N = 82-126 using the temperature dependent microscopic densities from relativistic mean Field theory with NL3 and IOPB-I parameter sets. These densities have been further used within coherent density Fluctuation model, for the calculations of NSE and its bulk and surface parts. At T = 0 MeV, there is a rise and fall trend in NSE and its volume and surface components with increasing mass number and an interestingly, a peak is observed at N = 100, which is a manifestation of deformed shell closure/magic number in these rare earth nuclei. This result is of important consequence as these N= 100 nuclei can serve as waiting point in the nucleosynthesis mechanism via r-process. This result is in consonance with our earlier, demonstrating the stability of nucleus, which had been experimentally conformed by Patel et al. in 2014 reporting the existence of deformed shell closure at N = 100 in ^{162} Sm and ^{164}Gd isotones.

Next, we have explored the thermal evolution of the NSE and its components. It is observed that at higher temperatures T = 1, 2 MeV, the value of NSE and its components decreases in comparison to at T = 0 MeV and peak shifts down-wards. Further, at T = 3 MeV the peak in the curve disappears and the studied quantities show constant character. Quite interestingly, the mass dependence of quadrupole deformation parameter β_2 at different temperatures also shows the trend of rise and fall with maxima near N = 100 and the curve shifts down at T = 1, 2 MeV compared to T = 0 MeV. At higher temperature, T = 3 MeV, all nuclei become spherical in shape. On comparison, it is noted that at T = 3MeV, due to spherical shape all nuclei in considered isotopic chain have nearly same symmetry energy. In other words, we found a correlation between temperature evolutions of deformation parameter β_2 and symmetry energy and its bulk and surface contributions. Also, the effect of temperature on the root mean square radii and neutron skin thickness in these neutron rich nuclei has been studied. The increase in root mean square radii and neutron skin thickness with temperature may have considerable effect on the neutron stars and astrophysical processes.

(Manpreet Kaur, Abdul Quddus, M. Bhuyan, B. V. Carlosn, A. Shakeb and S.K. Patra)

4. Investigation of proton radioactivity in neutron deficient nuclei:

The study of nucleon emissions from ground state of spherical as well as deformed nuclei, facilitates to explore the limits of nuclear existence within nuclear landscape. Moreover, the observation of new radioactive decay paths in exotic nuclei act as a significant probe to extract information about inter nuclear potential and nuclear structure. Since the proton binding of an element decreases with decreased neutron number, it is expected that there exists p-drip line beyond which nuclei become unstable against proton emission. Therefore, analogous to α–decay, the proton radioactivity becomes energetically feasible. In this work, we have studied the ground state properties of neutron deficient nuclei in the region from I to Bi with Z = 53 -83 and N = 56 -102 within the relativistic mean field formalism with NL3, DDME-1, DDME-2 parameterizations, with deformed consideration of nuclei. The negative value of neutron skin thickness shows that radial distribution of proton is extended compared to that of neutron and small thickness of aggregated protons in the outer part of nucleus is loosely bound which is prone to p-emission. The quasi bound states from which the p-emission is probable are determined. Further, the proton decay half-lives are calculated using WKB approximation, by taking into account the experimental Q-values. The total interaction potential comprises of Coulomb, nuclear and centrifugal potentials and the nuclear potential is obtained by using double folding method with realistic M3Y effective nucleon-nucleon interaction and spherical equivalent densities obtained from the deformed densities. The results present that decay half-lives are highly sensitive to orbital angular momentum of outgoing proton. The calculated half-lives for different neutron deficient nuclei are in agreement with experimental data.

(Trupti Sahoo, Manpreet Kaur, R. N. Panda, and S. K. Patra)

5. Nuclear Reaction Studies

The fission decay mechanism of various ^{212,213,215,217} at isotopes formed in tightly (^{3,4}He) and loosely bound (^{6,8}He) projectile induced reactions on ^{209}Bi target, is studied within the framework of dynamical cluster-decay model (DCM), over a wide range of excitation energies spread across the Coulomb barrier. By optimizing appropriate neck-length parameter ΔR, the fission cross-sections are calculated for ^{212,213,215}At compound nuclei (CN) at above barrier energies, where some experimental data is available. The DCM calculations are extended at below barrier region for these nuclei, and for one more reaction ^{8}He + ^{209}Bi $\rightarrow$ ^{217} at, using the systematics of ^{212,213,215}At isotopes. The magnitude of fission cross-sections increase with the addition of neutrons in the He projectile (or say in the at compound nucleus since the target nucleus of each reaction is same). To obtain better description of fission dynamics involved for Neutron-deficient and neutron-rich He-induced reactions, the fragmentation potential and preformation probability P0 of decaying fragments are analyzed along with corresponding barrier tunneling probability P. The session fragment mass distributions are explored for all at isotopes, and most probable fission fragments are identified. It has been observed that asymmetric fission forms the predominant decay mode for all isotopes, although a minor hump with very small preformation factor appears around symmetric fragments for lighter ^{212,213} at nuclei. Finally, the N/Z dependence of fission cross-sections and most probable decaying fragments is explored in view of fragmentation structure and related cross-sectional yields.

(Amandeep Kaur, Gurjit Kaur, S. K. Patra and Manoj K. Sharma)

6. Nuclear Equation of States and Neutron Stars

Nuclear effective interactions are considered as the vital tool to guide into the region of the high degree of asymmetry and density. We take varieties of parameter sets of RMF model to show the parametric dependence of the neutron and hyperon star. We add ϕ_0 meson to σ–ω–ρ model. The effects of ϕ_0 meson on the equation of state and consequently on the maximum mass of the hyperon star is discussed. Due to the inclusion of 0 -meson the threshold of the density of different hyperon production shifts to higher density region. The effects of the hyperon-meson coupling constants on the maximum mass-radius profiles of the hyperon stars are discussed.

(S. K. Biswal, S. K. Patra and Shan-Gui Zhou)

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. 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 Production of Λ (1520) resonance at ALICE Energies:

The production of Λ(1520) baryonic resonance has been measured in pp and p–Pb collisions at 7 TeV and 5.02 TeV, respectively. This mass of the resonance is reconstructed via its hadronic decay channel (p_K) with the ALICE detector. The yield and $<p_T>$ are calculated in pp and p-Pb collisions. It has been found that Λ(1520) follows the mass ordering in $<p_T>$ for both the collision systems. The onset of radial flow from p_T differential ratios of Λ(1520) over *n*, K and p has been studied. The yield ratio of this resonance over its ground state particle, Λ(1115) shows negligible effect of hadronic scattering medium on its yield in p-Pb collisions. The p_T integrated yield ratios over *n* and proton shows strangeness could be a key factor of yield enhancement in higher multiplicity events.

Λη

(For ALICE Collaboration: S. Sahoo, P. K. Sahu, R.C. Baral and B. Mohanty)

1.2 Ks/ Λ/Anti-Λ/Xi/Anti-Xi in U+U 193 GeV :

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 ongoing. 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:

A) Hardware: A quadruple GEM detector prototype is built in IOP, HED lab and tested with Ar/CO_2 gas mixture in 70:30 ratio. Initial characterizations for the detector are performed by measuring the count rate and anode current with cosmic muons. The detector is taken to GSI, Germany and tested with Fe^{55} X-ray source and an X-ray generator. The measurement is done with a high gain preamplifier. The gain and energy resolution are measured for different voltage setting. The exponential nature of gas gain with applied voltage is observed. At 1600 V a typical gain is ~ 450 and the energy resolution is found to be ~ 14% (σ). The anode current is also measured for different configurations with both Fe^{55} source and X-ray generator.

Since flow rate optimization is needed for the further study, the GEM detector is tested with different gas flow rates. For this measurement Am^{241} radioactive source is used. The count rate

variations and current variations are observed at different flow rates with different operating GEM voltages. The flow rates are recorded with a mass flow sensor built in house.

A single layer GEM detector is also fabricated for the estimation of Ion Back Flow fraction. The voltages are provided to each electrode individually. For the measurement of current from each channel with different settings, a picoammeter is used. The variation of Ion back flow fraction is observed with changing drift field, induction field as well as different GEM voltages.

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

i) Construction of a single GEM detector using indigenous anode plate

A prototype of single Gas Electron Multiplier (GEM) detector is fabricated in our laboratory using a single GEM foil of size 10×10 cm^2, a cathode plate and an anode plate (which is designed in our laboratory). The anode plate used is a single readout pad. The detector is operated using Argon and CO_2 gas mixtures in proportion of 70:30. High voltage connections are provided individually to the drift plane, GEM foil and induction plane. The anode plate used in this work is a single readout pad. Preliminary testing results show that this detector can withstand a voltage up to 460 V across the GEM foil and the anode plate without any spark. The tested results are presented in this article.

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

ii) Study of ion backflow fraction for GEM based detector:

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

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

iii) Ion Beam based characterization of Triple GEM Detector

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 X 10 cm^2 was fabricated and characterised using Fe^{55} source at Institute of Physics, Bhubaneswar. In this report, we used the same GEM detector to characterise 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, S. Swain, A. Tripathy, S. Sahu and B. Maillick)

B) 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, S. Dani and P. K. Sahu, M. M. Mondal)

3. Measurement of top quark Yukawa coupling in final states with a tau lepton at LHC

In Standard Model (SM), the Higgs boson to fermion coupling is proportional to fermion mass. Thus, 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. Though, the top quark Yukawa coupling is measured indirectly from the Higgs boson production in gluon fusion process, and agrees well with the SM expectation, it 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 (tt(bar)H) provides the most precise model independent measurement of y_t.

We are involved in the searches for tt(bar)H 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 sensitivity of the analysis is enhanced by means of two different multivariate analysis techniques: by the matrix element method (MEM) and by the boosted decision trees (BDT). Our group has played a leading role in developing the BDT discriminant 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 is published in PRL. Furthermore, we have 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. The analysis of full run-2 data is still ongoing.

(*A Nayak and Collaborators*)

4. Measurement of Higgs 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, is being studied. The method retains significant amount of the discriminating power, however, it is significantly affected by the detector resolution. Our group is making significant contributions to this measurement. We have made generator level studies and preliminary studies with detector simulation. We are working towards a publication with full 13 TeV data recorded by CMS.

(*A Nayak, Vinaya Krishna, Diwakar and Collaborators*)

5. Contributions to the development of reconstruction and identification of τ leptons in their decays to hadrons

The reconstruction and identification of τ lepton in their decays to hadrons and tau neutrino is crucial for the studies of Higgs boson and many other new physics searches at LHC. The CMS group at IOP plays a leading role in the development of reconstruction and identification algorithms of the hadronic decays of τ leptons (τ_h). In particular, we played leading role in development of multivariate (MVA) isolation for Run-2 of LHC using boosted decision trees (BDT). The MVA-based isolation discriminants provide a factor of two reductions in jet $\rightarrow \tau_h$ mis-identification probability, while retaining same τ_h efficiency as compared to the isolation sum discriminants. The group played leading role in the overall coordination of the offline tau identification developments and is also played major role in measuring the performance of the identification algorithms in proton-proton collision data recorded during 2016. The detailed description of the algorithm developments and performance results with 2016 data have been published in JINST, where A Nayak was assigned as contact author by the CMS collaboration.

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. Our group also made major contribution to the validation and performance measurements of the tau lepton triggers during 2018 data taking.

(*A Nayak, Vinaya Krishna and Collaborators*)

6. Development of Jet and Missing Transverse Energy Triggers for the CMS experiment

The CMS group at IOP is 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. 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. Our group is

playing a leading role in these activities since mid 2016. In addition to the coordination task the group is also contributing to the various aspects of the trigger development, such as studying the response and resolution of the jets at HLT, developing trigger menu, measuring the performance of the trigger in data, and so on. The performances of the jet triggers in 2018 data are shown in Fig. 1, which shows good efficiency for the online reconstruction of these objects with respect to the offline.

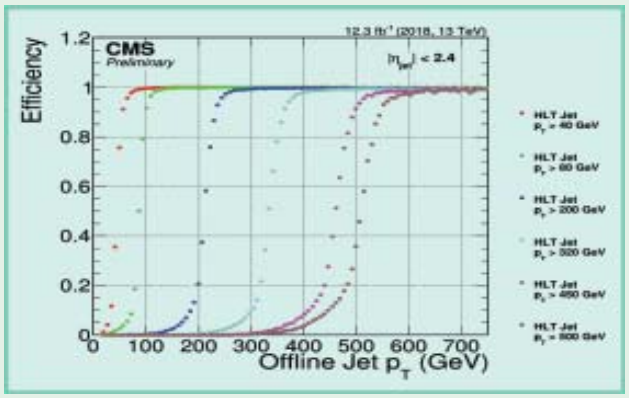


Fig.-1: The trigger efficiencies measured in data recorded during 2018 as a function of the offline reconstructed jet transverse momentum.

(*A Nayak, Bhakti Chitroda, Diwakar and Collaborators*)

7. R&D for buliding a functional test setup to test the silicon-strip tracker detector modules.

India-CMS 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. The tests need to be performed at room and operating temperatures to establish the functioning of those modules before they are shipped to CERN for installation in the CMS detector.

(A. Nayak)

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. Mutual Uncertainty, Conditional Uncertainty and Strong Sub-Additivity

Using the variance-based uncertainty, we introduce a new concept called as the mutual uncertainty between two observables in a given quantum state which enjoys similar features like the mutual information for two random variables. Further, we define the conditional uncertainty and show that conditioning on more observable reduces the uncertainty. Given three observables, we prove a 'strong sub-additivity' theorem for the conditional uncertainty under certain condition. As an application, we show that for pure product two-qubit states, the mutual uncertainty is bounded by $2 - \sqrt{2} = 0.586$ and if it is greater than this value then it indicates that the state is entangled. For mixed two-qubit states, we prove that the mutual uncertainty for product, classical-classical, and classical-quantum state also takes a universal value 0.586. We also show how to detect quantum steering using the mutual uncertainty between two observables. Our results may open up a new direction of exploration in quantum theory and quantum information using the mutual uncertainty, conditional uncertainty and the strong sub-additivity for multiple observables.

(*P. Agarwal, Sk Sazim, Satyabrata Adhikari, Arun K. Pati*)

2. Two-qubit mixed states and teleportation fidelity: Purity, concurrence, and Beyond

To explore the properties of a two-qubit mixed state, we consider quantum teleportation. The fidelity of a teleported state depends on the resource state purity and entanglement, as characterized by concurrence. Concurrence and purity are functions of state parameters. However, it turns out that a state with larger purity and concurrence, may have comparatively smaller fidelity. By computing teleportation fidelity, concurrence and purity for two-qubit X-states, we show it explicitly. We further show that fidelity changes monotonically with respect to functions of parameters – other than concurrence and purity. A state with smaller concurrence and purity, but larger value of one of these functions has larger fidelity. These functions, thus characterize nonlocal classical and/or quantum properties of the state that are not captured by purity and concurrence alone. In particular, concurrence is not enough to characterize the entanglement properties of a two-qubit mixed state.

(*P. Agarwal, Sumit Nandi, Arpan Das, Chandan Datta*)

3. Minimal scenario facet Bell inequalities for multi-qubit states

Facet inequalities play an important role in detecting the nonlocality of a quantum state. The number of such inequalities depends on the Bell test scenario. With the increase in the number of parties, dimensionality of the Hilbert space, or/and the number of measurements, there are more nontrivial facet inequalities. For a specific scenario, involving two dichotomic measurement settings for two parties and one dichotomic measurement by other parties, the local polytope has only one non-trivial facet, which is the lifted version of Clauser-Horner Shimony-Holt (CHSH) inequality? This measurement scenario for a multipartite state may be considered as minimal scenario involving multipartite correlations that can detect nonlocality. We show that this

inequality is violated by all generalized GHZ states, which satisfies any full correlation Bell inequality with two dichotomic measurement settings per party. This inequality is also shown to be violated by any genuinely entangled three qubit pure state numerically.

(*P. Agarwal, Arpan Das and Chandan Datta*)

4. Resource state structure for cooperative quantum key distribution

Quantum entanglement plays a pivotal role in a number of communication protocols, like secret sharing and quantum cryptography. We consider a scenario where more than two parties are involved in a protocol and they share a multipartite entangled state. In particular, we introduce the protocol of cooperative quantum key distribution (CoQKD). In this protocol, two parties, Alice and Bob establish a key with the co-operation of other parties. Other parties control whether Alice and Bob can establish the key, its security and the key rate. We discuss the case of three parties in detail and find the necessary suitable resource states. We discuss the controlling power of the third party, Charlie. We also examine the usefulness of this new resource state for generating conference key and for cooperative teleportation. In the case of conference key, we find that recently introduced Bell inequalities can be useful to establish the security. We also generalize the scenario to more than three parties.

(*P. Agarwal, Arpan Das, Sumit Nandi, Sk Sazim*)

2.5 Experimental Condensed Matter Physics

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

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

1. Detecting Arsenic contamination in water using organic molecules

We are utilizing thin films of organic molecules for detecting Arsenic contamination in Water. Arsenic contamination of Water is a serious concern in many countries and its easy detection is necessary for the control of contamination. XPS, FTIR have been performed to study the interaction and the specific site of attachment of Arsenic on the molecules.

(S. Varma, P. A. Dowben at Univ. Nebraska, Lincoln, USA)

2. Metal doped Sulphides for Solar Cells applications

We are investigating metal doped thin films of many Sulphide compounds and studying their wavelength dependent abosorbance properties. XPS, UPS and UV-Vis measurements have been per-formed. The films also exhibit work function modification.

(S. Varma, P.A. Dowben at Univ. Nebraska, Lincoln, USA)

3. Ion irradiated TiO_2 films exhibit anatase to Rutile Phase transition and

Resistive switching behavior Ion implantation of TiO2 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 with application in

S. Varma, A. Manna, Shalik R. Joshi (Ulsan National Institute of Science and Technology, Korea), Aloke Kanjilal(Shiv Nadar Univ.), D. Kanjilal (IUAC, Delhi))

4. Developed metal doped ZnO sensor for Amperometric Glucose sensing measurements

We have developed Amperometric Glucose sensor. For this coelectrodeposition of ZnO with small concentration of metal was carried out in the growth cell. No- Enzymes, like glucose oxidase were used for the sensing measurements. Glucose sensing is demon-strated by CV and time dependendent measurements. The metal-ZnO nanostructures show wavelength dependent bandgap changes as well as enhanced absorption proper-ties.

(S. Varma, A. Manna, S. Srivastava (IIT Khargpur)

5. Scaling properties of nanostructures created via ion irradiation on thin TiO2 films

Ion implantation of TiO2 thin films produces nanostructures and ripple patterns. Ion Implantation was carried out at IUAC, New Delhi. 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 have been studied by utilizing all the results in combination. The roughness and growth exponent behavior has been studied.

(S. Varma, A. Manna, A. Kanjilal and D. Kanjilal (IUAC N. Delhi)

6. Enhanced photocatalytic activity from aligned ZnO nanorods

Aligned ZnO nanorods were synthesized by

hydrothermal method. Morphological, structural, photoabsorbance and photoluminescence studies have been carried out using field emission scanning electron microscopy (FE-SEM), grazing incidence X-ray diffraction (GIXRD), Raman, UV-visible and Photoluminescence spectroscopy. Results show that crystallinity and alignment of ZnO NRs lead to good photocatalytic activity in the presence of visible light.

(S.Varma, P. Dash, A. Manna, P. K. Sahoo(NISER), N. C. Mishra (Utkal Univ.)

7. Interaction of circular DNA with SiO_x and TiO_2 Surfaces

SiO_x and TiO_2 Surfaces were modified with ion beams to produce efficient surfaces for DNA conjugation. Thee surfaces were interacted with circular DNA. These surfaces respectively indicate a hydrophobic and hydrophilic behavior. Scanning probe microscopy (SPM) and Angle Resolved X-ray Photoelectron Spectroscopy (ARXPS) studies have been carried. Combined studies display that the concentration of elements varies as a function of depth which is responsible for the DNA interaction.

S. Varma, Indrani Mishra (IIT N. Delhi), S. Majumder (NIT-Patna), Shalik R. Joshi (Ulsan National Institute of Science and Technology, Korea) and U. Subudhi (IMMT))

8. 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 such as; the effect of proximity of TIs with superconductors, correlated and magnetic materials, the spin helical SSs of TIs to build up some novel devices, 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 interactions (SOI) and the near Fermi level (E_f) electronic structure can also lead to other distinct systems, like Weyl semimetals, topological crystalline insulators, topological Dirac semimetals etc. The *SSs* in TIs are characterized by the time reversal invariant $Z_2(\nu_0,\nu)$. TI systems fall into the category of strong or weak according to the ν_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. We have been studying the band structure of various TIs using both experimental ARPES as well as theoretical DFT methods, especially for tuning the Dirac node and understanding the dynamics of the fermions. During the year we have undertaken ARPES studies on compositions of BiSe, $Bi_{2-x}Cu_xSe$, Bi_{1-}

$_xSb_xSe$ and Weyl semimatals like WTe_2, $ZrTe_2$ etc using both laboratory ARPES system at IOP and Synchrotron Radiation facility at Elettra, Italy. In our recent ARPES study on the week topological insulator BiSe we showed the presence of Dirac like linearly dispersive SSBs around the Γ point and with a small (8%) Sb doping the SSBs deviate from the Dirac like dispersion. This behavior is quite different from that of the SSBs and their evolution with doping in known TIs of the Bi chalcogenide family. The FS composed by the SSBs of BiSe does not show any hexagonal warping. The most important observation of this study is the asymmetry in the spectral weight of the SSBs between the positive and negative K_{11} directions which changes with the polarization of the exciting photon. This asymmetry in the intensity of SSB of negative and positive K_{11} gradually switches to opposite direction as photon energy varies. This indicates the spin polarization of the SSB which can be associated to the strong coupling between the spin and orbital component of the SSB.

(Prof. B. R. Sekhar)

9. A major part of the research work was on the growth, characterization and application of 2D layered nanostructures, in particular MoOx nanostructures. Extensive works were carried out growing α-MoO_3 and meta-stable β-MoO_3 nanostructures on various substrates and various 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. The three parts of any materials system development involves, growth, characterization and applications. This year work focuses on these three parts related to MoOx nanostructures. One of the idea was to grow MoO_x nanostrcutures under clean environment (like using MBE under UHV) and look at possibility of growing ordered 2D layered structures, such as, MoO_x nanostructures under MBE conditions. It is a challenging task as often there is a large amount of lattice mismatch with the substrate besides weak inter-planar forces in the 2D layered structures.

The growth and characteristics of defect free, mixed phase free metastable molybdenum trioxide (β-MoO_3) on varied substrates and MoO_2 and then the structural phase transformation from β-MoO_3 to MoO_2 and then to Mo by simple thermal reduction process in UHV condition. A part of the work was devoted to structural characterization of MoO_x nanostructures, such as, elemental composition, thickness, shape and size, order in the organization using several experimental methods. The effective thickness, composition and the oxygen concentration of the molybdenum oxide thin films nanostructures were determined by using the resonant Rutherford backscattering spectrometry (RBS). In resonant RBS measurements, 3.05 MeV alpha particles were used to probe, as it is known that the Rutherford cross-section is enhanced from the Oxygen atoms. Extensive use of electron microscopy methods, such as, scanning electron microscopy and transmission electron microscopy were used for size, shape, ordering, crystalline structure and composition of the

grown nanostructures. UV-Vis spectroscopy and Kelvin probe microscopy methods were used to determine the band gap and work function of the structures. X-ray photoelectron spectroscopy was used to determine the chemical bonding information. The effect of different film thickness of molybdenum oxide nanostructures on the optical band gap, local work function and field emission have discussed in detail. The role of noble metal (Au and Ag) nanostructures acting as catalyst for the growth of MoO3 was studied. The experimental investigations using SEM - EDS method, showed that the Au nanostructures are better catalyst particles for MoO_x nanostructure growth. The role of annealing environment on structural, optical, field emission properties of MoO_3 thin films has also been presented in this work.

We report on the synthesis and UV–vis photodetection application of p-type MoO_2 nanostructures (NSs) on Si substrate. β-MoO_2 NSs have been synthesized from previously grown α-MoO3 structures/n-type Si via a hydrogenation process at 450 °C. After hydrogenation, the α-MoO_3 structures were completely converted into β-MoO_2 NSs without the presence of sub-oxidized phases of molybdenum oxide. The as-grown NSs exhibited very good p-type electrical conductivity of ≈ 2.02 × 10^3 S–cm^{-1} with hole mobility of ≈ 7.8 ± 1.3 cm^2–V^{-1}–Sec^{-1}. To explore optoelectronic properties of p-type β-MoO_2 NSs, we have fabricated a p-MoO_2/n-Si heterojunction photodetector device with Au as the top and Al as the bottom contacts. The device exhibits peak photoresponsivity of ≈ 0.155 A W^{-1} with maximum detectivity ≈ 1.28 × 1011 cm–Hz1/2–W^{-1} and 44% external quantum efficiency around ≈ 436 nm, following the highest photoresponse (I ph/I d ≈ 6.4 × 10^2) and good response speed (rise time ~29 ms and decay time ~38 ms) at -1.5 V. Importantly, this device also shows good self-powered high-speed (rise time ~ 47 ms and decay time ~70 ms) photodetection performance with peak ≈ 45 mA W^{-1}. This broadband UV-visible light detection feature can be attributed to the coordinated effects of MoO2 band-edge absorption, interfacial defects and self-absorption in Si. The photodetection behavior of the device has been understood by proposed energy-band diagrams with the help of an experimentally derived work function, band gap and valence band maximum position of MoO_2 NSs.

(Prof. P. V. Satyam)

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

(a) Ion-beam fabrication of self-organized patterned substrates

We are working on fabrication of self-organized patterned semiconductor substrates with the help of low-to-medium energy (0.1-60 keV) ions and trying to understand pattern formation in light of different experimental parameters and Monte-Carlo simulation studies. Interestingly, usage of keV Au ions leads to nanowire-like patterned Ge substrates with extreme regularity up to tens of micro-metres. On the other hand, at low ion energies, ripples are formed on Si surface which undergoes a transition to facets (in the low energy regime) under a stipulated angular window of the incident ion beams. On the other hand, low energy Ar and Kr-ion bombardment at elevated temperatures and high fluences lead to the

formation of crystalline ripples, dots, and nanowires on different III-V semiconductor surfaces, viz. InP, GaAs, GaSb, InP, and InSb under the reverse epitaxy process. Different types of patterned surfaces are fabricated by us towards their nanoscale functionalization, viz. plasmonics, solar cells, and nanoscale magnetism where we use the patterned substrates as templates for growth of low-dimensional thin films using various deposition methods.

(b) Nanoscale functionalization of nanopatterned semiconductor surfaces

(i) Anti-reflection of oxide thin films grown on patterned silicon surfaces

Low energy ion-beam fabricated nanorippled- and nanofacted-Si substrates show good anti-reflection property. These surfaces are successfully used for growth of oxide thin films. For example, we have shown the efficacy of zinc-doped tin oxide (ZTO) films grown on nanorippled- and nanofaceted-Si surfaces towards reducing optical reflection loss.

(ii) Tailoring anisotropic optical properties of gold nanoparticles decorated rippled-Si

Low energy ion-beam fabricated nanorippled-Si substrates have anisotropic morphological nature which are being employed by us as templates to decorate with Au nanoparticles to tune their optical property. In this case, we are growing Au nanoparticles at different growth angles on rippled-Si substrates. Spectroscopic ellipsometry in conjunction with UV-Vis spectroscopic measurements show growth angle-dependent shifts in the signals. The results are compared with the Au nanostructures grown on pristine-Si substrates. These Au nanoparticle-decorated rippled-Si substrates are also being investigated as surface enhanced Raman scattering substrates for their potential use in cancer detection.

(iii) Cold cathode electron emission

Gold nanoparticle-decorated nanofaceted-silicon substrates show extraordinary cold cathode electron emission at unprecedented low turn-on fields following Fowler-Nordheim tunneling process. It is interesting to note that while as-prepared Si-nanofacets show less than 0.5 V μm^{-1} turn-on field, upon decorating the same by Au nanoparticles (grown at different angles), the turn-on field can be pushed down even further to an extremely low turn-on field (0.27 V μm^{-1}).

(iv) Magnetic anisotropy in Co thin films on nanowire-like patterned-Ge substrates

Strong uniaxial magnetic anisotropy is observed in conformally grown cobalt thin films on nanowire-like patterned-Ge substrates. Thin films were deposited at different oblique angles of incidence by RF magnetron sputtering technique. The results are compared with those obtained for Co films grown on pristine-Ge substrates. Our results reveal that magnetic anisotropy prevails along the easy axis of magnetization parallel to the direction of patterns. In addition, a complete spin re-orientation is also observed in Co films depending on the orientation of the applied external magnetic field with respect to the pattern wave-vector.

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

(a) Thin film growth using DC/RF magnetron sputtering

We are studying growth of transparent conducting oxides (TCOs), hole-blocking oxides, and other active layers in the form of thin films on glass and silicon substrates. The main objective is to optimize the growth of different oxide materials under varying experimental conditions to use them in photovoltaic cells.

(b) Local probe electrical transport property of zinc-doped tin oxide thin films

We demonstrate tunable nanoscale charge transport in Zn-doped SnO_2 (ZTO) thin film using conductive atomic force microscopy. We show that charge transport across a ZTO layer can be tuned by applying an external nano-Newton force. We also demonstrate that the work function of Zn-doped SnO_2 (ZTO) can be tuned externally by applying an electric field. Our experimental investigations using Kelvin probe force microscopy show that by applying a positive or negative tip bias, the work function of AZO film can be enhanced or reduced, which corroborates well with the observed charge transport using conductive atomic force microscopy. Tuning the work function of ZTO by applying an external electric field is not only important to control the charge transport across it, but also to design an Ohmic contact for advanced functional device.

(c) Study of hole-blocking property of WO_3 and MoO_3 thin films

We are studying the hole-blocking properties of WO_3 and MoO_3 layers for their applications in photovoltaic cells. X-ray diffraction data reveal the amorphous nature of as-grown oxide films which undergo a transition to crystalline states after annealing.

II. Resistive switching behavior inTiO_2 thin films

We are working on thin films of TiO_2 grown by pulsed laser deposition (PLD) and RF sputtering techniques. The films are found to be smooth and uniform over reasonably large surface areas and demonstrate unipolar resistive switching behavior. In addition, we have shown visible wavelength-dependent systematic change in the switching voltage at various current compliance values which adds up an extra control parameter in conventional resistive switching based memory devices. As a second step, we are tailoring the resistive switching property of these films using several ion beams having different energies (5-60 keV). For this purpose, besides bulk resistive switching we also employ local probe-based conductive atomic force microscopy (cAFM) to address the underlying mechanisms, based on ion-matter interaction, leading to the tunable resistive switching behavior in TiO_2 films. Mostly our ECR ion source-based low-to-medium energy ion-beam facility is used to extract ions up to 25 keV, while ion energies higher than that are being obtained from the IUAC ECR ion source-based facility.

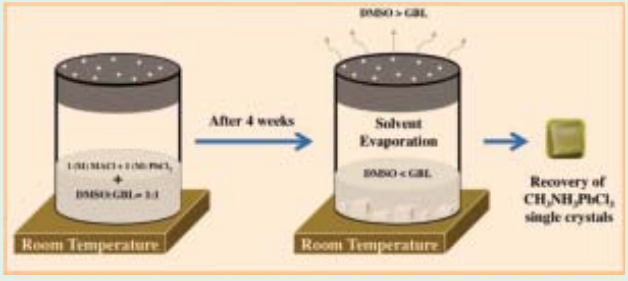
(Prof. T. Som)

11. My group is actively involved in material science research and tailoring properties of materials by doping or by band modifications. Our research interest also extends to various advanced functional materials which have potential technological applications. Some representative abstracts of our research work carried out in last one year which range from synthesizing organic compounds, single crystal analysis, catalysis, optical and electron spectroscopy, magnetic refrigerant, ion beam

research, multiferroics and theoretical modelling are presented below.

A. Room Temperature Growth of $CH_3NH_3PbCl_3$ Single Crystals by Solvent Evaporation Method

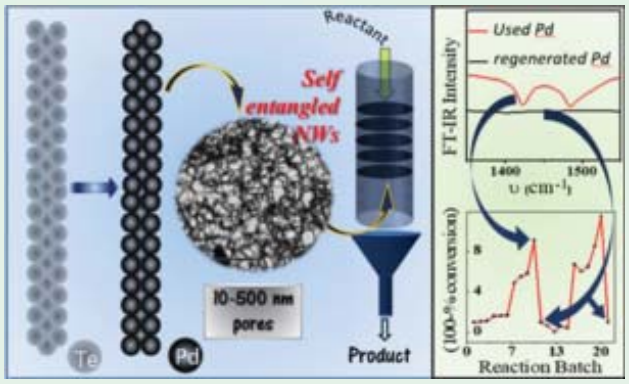
We report a new route to synthesize high-quality, large-size crystals of $CH_3NH_3PbCl_3$ through proper selection of Dimethyl sulfoxide (DSMO) – gamma-Butyrolactone (GBL) solution in which lead (II) chloride (PbCl2) and methylammonium chloride (MACl) were dissolved and the precursor solution was kept at room temperature without any disturbance. GBL has higher boiling point than DMSO, hence, DMSO vaporizes much faster and steers to have more anti-solvent contained reaction mixture condition, eventually leading to the growth of large rectangular shaped (8 X 5 X 1 mm), highly transparent, colorless and high-quality MAPbCl3 single crystals. We carried out detailed evaluation of the structural, electronic, optical and electrical properties of these crystals. Our XPS studies suggested that organic–inorganic halide perovskites are very sensitive to X-ray-induced damage, and hence, their properties may get altered. Also, photoluminescence studies displayed two peak spectra, indicating coexistence of order–disorder domains of CH_3NH_3 in the sample. Further observation of low defect concentration and longer diffusion length indicates that crystals grown by the presented method can offer promising solutions for optoelectronic devices.



Rectangular shaped, high crystalline quality, defect free, and colorless 3D perovskite single crystals of CH3NH3PbCl3 was grown using solvent evaporation method at room temperature for the first time.

B. Self-immobilized Pd nanowires as an excellent platform for a continuous flow reactor: efficiency, stability and regeneration

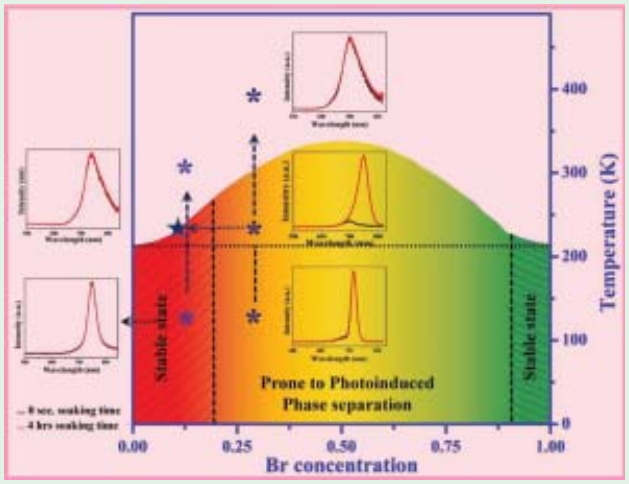
Despite extensive use of Pd nanocrystals as catalysts, the realization of a Pd-based continuous flow reactor remains a challenge. Difficulties arise due to ill-defined anchoring of the nanocrystals on a substrate and reactivity of the substrate under different reaction conditions. We demonstrate the first metal (Pd) nanowire-based catalytic flow reactor that can be used across different filtration platforms, wherein, reactants flow through a porous network of nanowires (10–1000 nm pore sizes) and the product can be collected as filtrate. Controlling the growth parameters and obtaining high aspect ratio of the nanowires (diameter = <"13 nm and length > 8000 nm) is necessary for successful fabrication of this flow reactor. The reactor performance is similar to a conventional reactor, but without requiring energy-expensive mechanical stirring. Synchrotron-based EXAFS studies were used to examine the catalyst microstructure and *Operando* FT-IR spectroscopic studies were used to devise a regenerative strategy. We show that after prolonged use, the catalyst performance can be regenerated up to 99% by a simple wash-off process without disturbing the catalyst bed. Thus, collection, regeneration and redispersion



processes of the catalyst in conventional industrial reactors can be avoided. Another important advantage is avoiding specific catalyst-anchoring substrates, which are not only expensive, but also non-universal in nature.

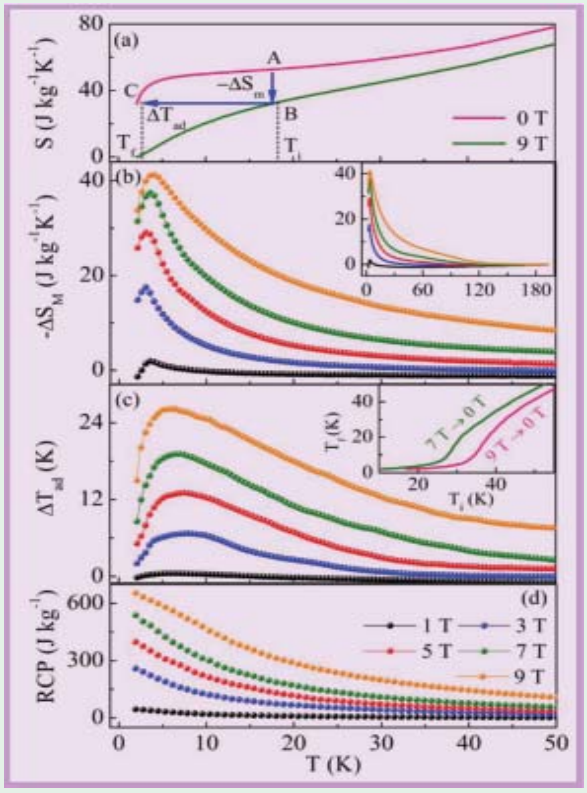
C. Temperature Dependent Photo-induced reversible Phase Separation in Mixed Halide Perovskite

It was prediced that tandem solar cells comprising of mixed halide perovskites and commercially available Si, Germanium or Copper indium gallium selenide cells could increase the solar cell efficiency beyond 40% % compared to the respective single junction cells. However, when mixed-halides perovskite was employed as solar cell absorber layers by replacing some I with Br, ($CH_3NH_3Pb(I_{1-x}Br_x)_3$) the increase in bandgap (of the perovskite material) did not yield a corresponding increase in open circuit voltage. Subsequently, it was realized that mixed I/Br perovskites underperforms as illumination induces a strong and reversible band gap feature (at lower band gap) which disappeared after several minutes in. Such insatiability arises due to light induced halide phase separation that leads to the formation of smaller-bandgap "trap" states. Herein, using temperature dependent photoluminescence studies, we show that the stated photoinduced phase separation occurs only in a narrow temperature range and above a particular bromine concentration. Our observation of disappearance of phase separation at elevated temperatures suggests the possibility that these tandem solar cells may indeed work better at elevated temperatures. Further, we provide the first experimental proof for the demixing transition temperature as predicted and also observe that demixing and remixing temperatures are pinned to crystallographic phase transition temperatures. Longer carrier lifetime of iodide-rich clusters is observed confirming the strong electron-phonon interaction (polaronic effect) which is absent in the initial mixed states.



D. GdCrO3: a potential candidate for low temperature magnetic refrigeration

$GdCrO_3$ shows a spectrum of interesting features, such as temperature induced magnetization reversal, spin flipping and spin reorientation, etc, which arise due to the competing magnetic interactions within and between Cr and Gd-sublattices. We observed that $GdCrO_3$ also exhibits a giant magnetocaloric effect (MCE) with a maximum entropy change of 36.97 J kg^{-1} K^{-1}, an adiabatic temperature

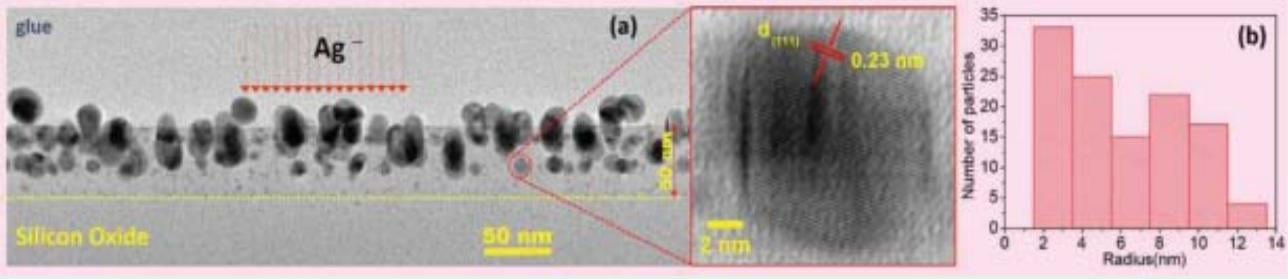


(a) Total entropy (*S*) as a function of temperature for zero field and 9 T applied field for GdCrO3, calculated from the heat capacity data. Arrows (AB) and (BC) represent the isothermal entropy change and isentropic temperature change, respectively. Temperature dependence of (b) isothermal entropy change (—Δ*SM*), (c) adiabatic temperature change (Δ*Tad*), and (d) RCP at various magnetic fields changes up to 9 T. The inset of (b) represents —Δ*SM* up to the temperature well above the magnetic ordering temperature (190 K) and the inset of (c) represents the final temperature (*Tf*) as a function of initial temperature (*Ti*) in the adiabatic demagnetization process for 9 T and 7 T magnetic fields.

change of 19.12 K and a refrigeration capacity of 542 J kg^{-1} for a field change of 7 T at low temperatures. Such an exceptionally large MCE arises from the suppression of the spin entropy associated with the suppression of spin reorientation transition, in addition to the Gd-ordering, which makes it one of the best candidates for magnetic refrigeration among all known potential low temperature magnetic refri

E. Angle dependent localized surface plasmon resonance from near surface implanted silver nanoparticles in SiO_2 thin film

Near surface silver nanoparticles embedded in silicon oxide were obtained by 40 keV negative ion implantation without the requirement of an annealing step. Ion beam induced local heating within the film leads to an exodiffusion of the silver ions towards the film surface, resulting in the protrusion of larger nanoparticles. Cross-sectional transmission electron microscopy reveals the presence of poly-disperse nanoparticles (NPs), ranging between 2 nm and 20 nm, at different depths of the SiO_2 film. The normal incidence reflectance spectrum shows a double kink feature in the vicinity of 400 nm, indicating a strong localized surface plasmon

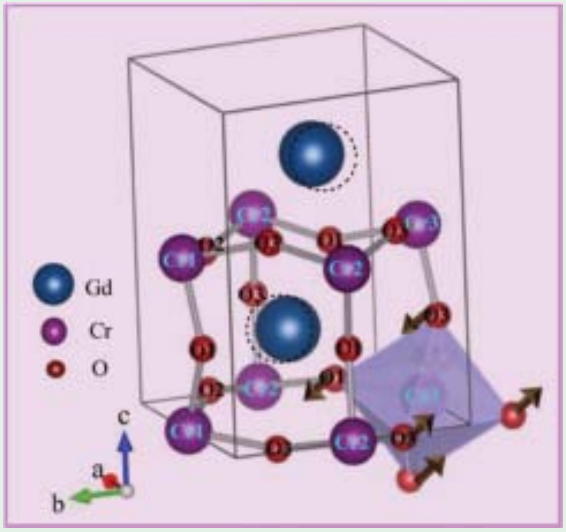


(a) The-cross sectional TEM image of the silver implanted SiO2 film/Si (100). The red arrows show the direction of silver ion implantation. Towards the right, the high resolution image shows the single crystalline nature of the formed Ag nanoparticles. (b) The corresponding size distribution of the Ag nanoparticles. *(Fig. of Sec-E)*

resonance (LSPR) from the embedded NPs. However, due to overlap of the bilayer interference and LSPR, the related features are difficult to separate. The ambiguity in associating the correct kink with the LSPR related absorption is cleared with the use of transfer matrix simulations in combination with an effective medium approximation. The simulations are further verified with angle dependent reflectance measurements. Additionally, transfer matrix simulation is also used to calculate the electric field intensity profile through the depth of the film, wherein an enhanced electric field intensity is predicted at the surface of the implanted films.

F. Role of local structural distortion in driving ferroelectricity in $GdCrO_3$

The family of rare-earth chromites like GdCrO3 has been recognized as promising systems for multiferroicity at reasonably high temperatures. But the conflicting observations of the ferroelectric behavior at relatively high temperature and the average centrosymmetric lattice (Pbnm) and magnetic structure (G-type) in these systems remained a puzzling issue in this series of compounds. Using temperature dependent synchrotron x-ray diffraction and extended x-ray absorption fine structure (EXAFS) studies we tried to understand the role of structural characteristics in driving the magnetoelectric multiferoic properties of GdCrO3. Our results suggest that the distortion in the structure appears to be associated with the off-center displacement of Gd-atoms together with octahedral rotations via displacement of the oxygen ions in GdCrO3. In addition, the magnetic coupling below magnetic transition temperature leads to additional distortion in the system via magnetostriction effect, playing a complementary role in the enhancement of ferro- electric polarization. Further, a comparative EXAFS study of GdCrO3 with a similar system YCrO3 suggests that oxygen environment of Gd in GdCrO3 is different from Y in YCrO3, which resulting in an orthorhombic Pna21 structure in GdCrO3 in contrast to the monoclinic P21 structure in YCrO3 .

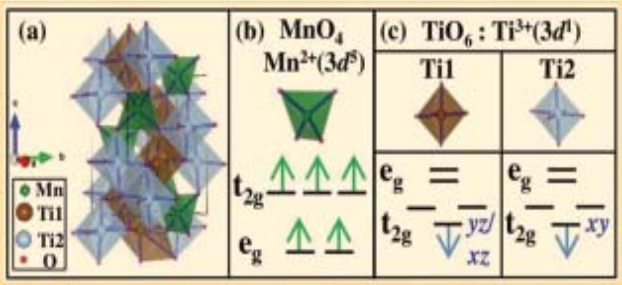


Visualization of displacement of oxygens around CrO6 octa- hedron (octahedral rotation), as indicated by the arrows and dashed circles represent possible displacement of Gd atoms in GdCrO3.

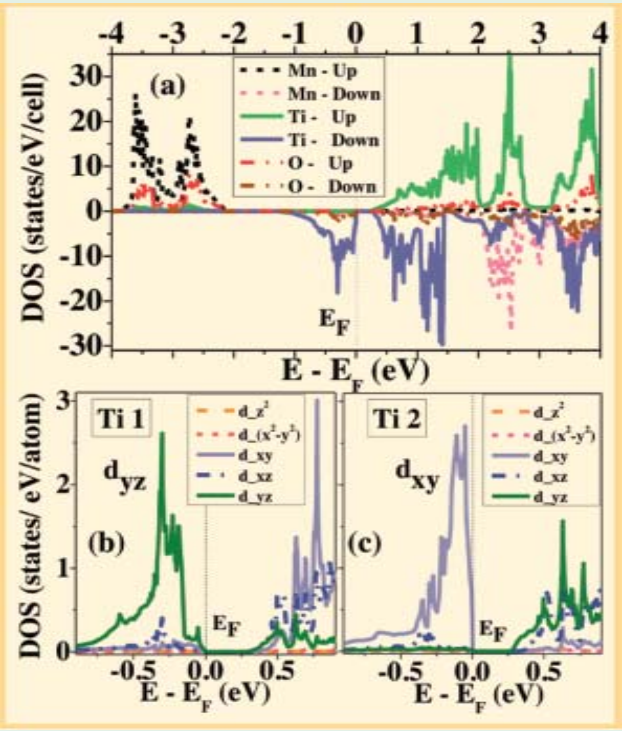
G. Tetramer Orbital-Ordering induced Lattice-Chirality in Ferrimagnetic, Polar MnTi2O4

Using density-functional theory calculations and experimental investigations on structural, magnetic and dielec- tric properties, we have elucidated a unique tetragonal ground state for MnTi2 O4 , a Ti3+ (3d 1)-ion containing spinel-oxide. With lowering of temperature around 164 K, cubic MnTi2O4 undergoes a structural transition into a polar P41 tetragonal structure

and at further lower temperatures, around 45 K, the system undergoes a paramagnetic to ferrimagnetic transition. Magnetic superexchange interactions involving Mn and Ti spins and minimization of strain energy associated with co-operative Jahn-Teller distortions plays a critical role in stabilization of the unique tetramer-orbital ordered ground state which further gives rise to lattice chirality through subtle Ti-Ti bond-length modulations.



(a) Schematic of the tetragonal $P4_1$ spinel structure of $MnTi_2O_4$ with MnO_4 tetrahedral units and two-kinds of TiO_6 octahedral units. Ground state orbital and spin configurations of (b) Mn^{2+} and (c) Ti^{3+}(Ti1 and Ti2) ions. The single Ti $3d^1$ electron occupies either the $|xz>$ or the $|yz>$ orbital for the Ti1 site and the $|xy>$ orbital for the Ti2 site.



Density-of-states (DOS) of $P4_1$ structure of $MnTi_2O_4$. (a) shows total-DOS for all atoms (Mn, Ti, O), (b) and (c) show partial-DOS for Ti1 d-levels and Ti2 d-levels, respectively

(Dr. Dinesh Topwal)

12. We report the intense room temperature ultraviolet photoluminescence (PL) emission from self-assembled vertically aligned ZnO nanorods grown directly on graphene. The PL intensities from ZnO nanorods grown on other van der Waal bulk solids such as highly oriented pyrolytic graphite (HOPG) and mica under the same experimental condition are also compared. The enhanced PL signal from ZnO nanorods grown on graphene is explained on the basis of lattice matching of ZnO with that of graphene leading to high crystal quality. Furthermore, the role of graphene plasmons on the enhanced PL signal is explored by studying the micro-PL mapping on a single nanorod lying horizontally on the graphene surface. The uniform and high PL intensity distribution are noticed along the central axis of the rod, and the intensity distribution decreases towards either side of the central axis. The occurrence of such intensity distribution is explained by resonant excitation of graphene plasmon near bandgap energy of ZnO, which is modulated by surface corrugation of graphene and followed by its transformation into propagating photon.

(Dr. S. Sahoo)

13. (a) Spin-orbit coupled $SrIrO_3$ thin films: Structural stability and related electrical transport properties.

Recent days have witnessed a surge of interest to study emergent topological effects induced by spin-orbit coupling. For systems having 5*d* transition metal ions like Ir, the energy scale of spin-orbit coupling that varies with Z^4 (Z is the atomic number) is comparable with those of the bandwidth W and the onsite Coulomb energy U unlike their *3d* counterparts. Therefore, *5d* transition metal oxides with delicate interplay among various energy scales are predicted to host exotic quantum phases like spin-orbit coupled Mott insulator, Weyl semimetal, correlated topological insulator, correlated Dirac semi-metal etc. Perovskite $SrIrO_3$ (SIO) is one of the representative members in this family that has drawn lots of attention. Interestingly, the emergence of a Dirac node and the observation of Dirac like semi-metallic character have been reported in SIO. Besides its novel semi-metallic character, SIO has been theoretically proposed as a key building block for engineering topological phases in various designed super-lattice structures. Despite its alluring electronic properties, the structural stability, strain relaxation, local lattice distortion under various thermodynamic conditions during film growth remains an issue.

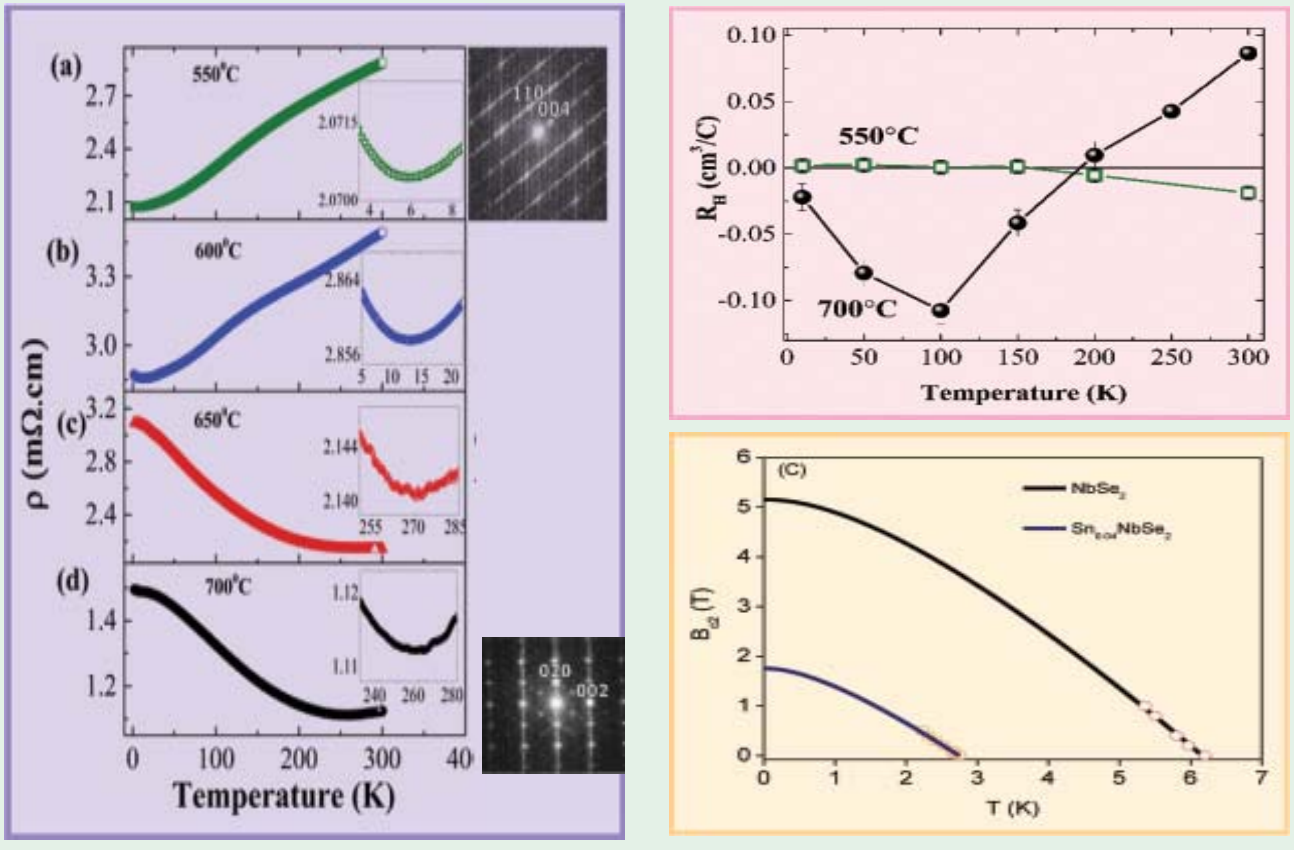


Fig. (a)- (d) are the plots of resistivity as a function of temperature for SIO films grown at different conditions. Insets to each figure show the transition from insulating-like to metal-like trend as the temperature is increased. Respective STEM images reveals distinct hexagonal and orthorhombic phases for films grown at 550°C and 700°C respectively. The right side plot shows the Hall coefficient (R_H) vs. temperature of SIO thin films grown at 550°C and 700°C respectively.

Metastable orthorhombic $SrIrO_3$ (SIO) is an arch-type spin-orbit coupled material. We tailor the growth of relatively thick SIO films that transform from bulk "6H-type" structure with monoclinic distortion to an orthorhombic lattice by controlling growth temperature. Extensive studies based on high resolution X-ray diffraction and transmission electron microscopy infer a two distinct structural phases of SIO. Electrical transport reveals a weak temperature dependent semi-metallic character for both phases. However, the temperature dependent Hall-coefficient for the orthorhombic SIO exhibits a prominent sign change, suggesting a multiband character in the vicinity of E_F. Interestingly, we found a robust sign change from negative to positive in the temperature dependent Hall coefficient for orthorhombic SIO film indicating a delicate balance between the hole and electron band contributing to the transport properties. This is along the lines of theoretical predictions that find a small overlap of parabolic whole bands with Dirac-like electron bands at the Fermi level. In essence, our study delineates the distinct structural and electrical transport properties of monoclinic vs orthorhombic SIO thin films which are important to understand the underlying electronic properties and structural stability of SIO thin for developing the future oxide electronic technology.

Reference: *Orthorhombic vs hexagonal epitaxial $SrIrO_3$ thin films: Structural stability and related electrical transport properties*

S. G. Bhat, N. Gauquelin, N. K. Sebastian, A. Sil, J. Verbeeck, **D Samal**, P S Anil Kumar, EPL 122, 28003 (2018) (**Editor's choice and highlights of 2018 in EPL**)

(b) The effect of Sn intercalation on the superconducting properties of 2H-$NbSe_2$

2H-$NbSe_2$ is known to be an archetype layered transitional metal dichalcogenide superconductor with a superconducting transition temperature of 7.3 K. We have investigated the influence of Sn intercalation on the superconducting properties of 2H-$NbSe_2$. Sn has been successfully intercalated up to 4 molar% in the $NbSe_2$. Magnetic and transport studies reveal a significant reduction of both superconducting transition temperature and upper critical field [T_c and B_{C2} (0)] upon Sn intercalatio **Fig.** 1 (a,b, and c). With a mere 4 mole% Sn intercalation, it is observed that T_c and B_{C2} (0) get suppressed by ~3.5K and 3T, respectively. Werthamer-Helfand-Hohenberg (WHH) analysis of magneto-transport data is performed to estimate B_{C2} (0). From the low temperature Raman scattering data **Fig.** 2 (a,b) in the normal phase of intercalated 2H-$NbSe_2$, it is inferred that the suppression of superconductivity cannot be ascribed to strengthening of charge density wave (CDW) ordering. Rather, the weakening of superconductivity is attributed to the observed increase of c-axis **Fig.** 2 (c) lattice parameter and the possible changes in the Fermi surface.

Reference: *The effect of Sn intercalation on the superconducting properties of 2H-NbSe2*

S Naik, G. K. Pradhan, S. G. Bhat, B. Behera, P.S. Anil Kumar, S.L. Samal, **D Samal,** Physica C: Superconductivity and its Applications, 561, 18 (2019)

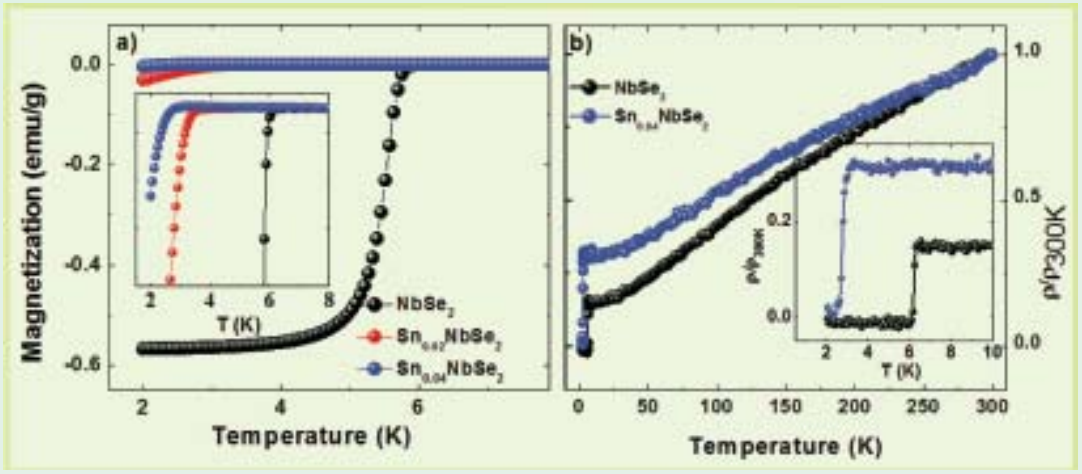


Fig. 1 **(a)** Temperature dependent zero field cooled (dc field 50 Oe) magnetization for Sn_xNbSe_2 (0 d″ *x* d″ 0.04) revealing superconducting transition. The inset shows the magnified view of superconducting transition. (b) Normalized temperature dependent resistivity for Sn_xNbSe_2 with $x = 0$ and $x = 0.04$. The inset shows the magnified view of superconducting transition (c) B_{C2}–T_c phase diagrams for $NbSe_2$ and $Sn_{0.04}NbSe_2$ extracted using WHH formalism. The inset shows the slope dB/dT in the vicinity of T_c.

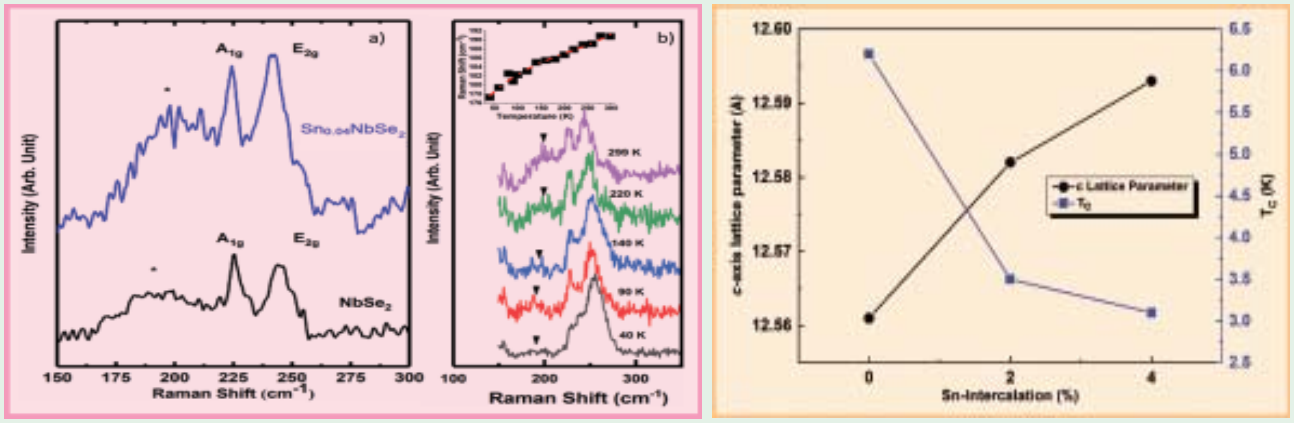


Fig. 2 a) Raman spectra of 2H-$NbSe_2$ and $Sn_{0.04}NbSe_2$. The broad feature (marked as *) around 190 cm^{-1} peak involving a second-order scattering process of two phonons. Disappearance of this mode is identified with CDW transition b) Temperature evolution of the Raman spectra of $Sn_{0.04}NbSe_2$ at representative temperatures. The spectra have been normalized to the highest intensity and vertically offset for clarity. The broad feature (marked by black arrow) survives until 40 K achieved in this experiment. The inset shows the red shifting of the soft mode position with temperature. The dashed line is a guide to the eye. The right hand side figure (Fig.2 c) shows the correlation of T_c *vs* c-axis lattice parameter upon Sn intercalation

(c) Evidence for exchange bias coupling at the perovskite/brownmillerite interface in spontaneously stabilised $SrCoO_3$/ $SrCoO_{2.5}$ bilayer

Interface effect in complex oxide thin film heterostructures lies at the vanguard of current research to design technologically relevant functionality and explore emergent physical phenomena. While most of the previous works focus on the perovskite/perovskite heterostructures, the study on perovskite/ brownmillerite interfaces remain at its infancy.

Here, we investigate spontaneously stabilized perovskite-ferromagnet ($SrCoO_{3-\delta}$)/ brown-millertite- antiferromagnet ($SrCoO_{2.5}$(SCO_{BM}))bi-layer with $T_N > T_C$ and discover an unconventional interfacial magnetic exchange bias effect. From magnetometry investigations, it is rationalized that the observed effect stems from the interfacial ferromagnet/ antiferromagnet coupling. The possibility for coupled ferromagnet/spinglass interface engendering such effect is ruled out. Strikingly, a finite coercive field persists in the paramagnetic state of $SrCoO_{3-ä}$ (SCO_{PC}) whereas the exchange bias field vanishes at T_C. We conjecture the observed effect to be due to the effective external quenched staggered field provided by the antiferromagtic layer for the ferromagnetic spins at the interface. Our results not only unveil a new paradigm to tailor the interfacial magnetic properties in oxide heterostructures without altering the cations at the interface, but also provide a purview to delve into the fundamental aspects of exchange bias in such unusual systems paving a big step forward in thin film magnetism.

Reference: *Evidence for exchange bias coupling at the perovskite/brownmillerite interface in spontaneously stabilised $SrCoO_3$/ $SrCoO_{2.5}$ bilayer*

B C Behera, Subhadip Jana, Shwetha G Bhat, N Gauquelin, G Tripathy, P S Anil Kumar, **D Samal**, Phys. Rev. B 99, 024425 (2019)

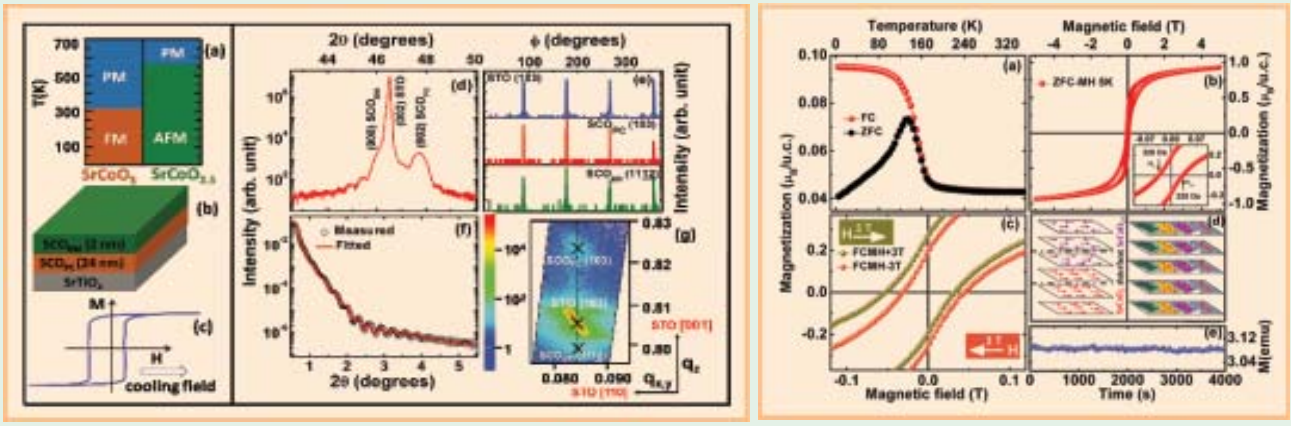


Fig.: left panel (a) schematic representation of magnetic ordering temperature for ferromagnetic $SrCoO_3$ and antiferromagnetic $SrCoO_{2.5}$, (b) layout of the designed [SCO_{PC}(~ 24nm)/SCO_{BM}(~ 2nm)] bi-layer on STO, (c) schematic magnetic hysteresis loop representing magnetic exchange bias (MEBE) under positive field cooling. Right panel (d)è-2è x-ray diffraction pattern, (e)Õ-scan along the asymmetric planes of STO(103), SCO_{PC}(103), SCO_{BM}(1112), (f) measured and fitted x-ray reflectivity, and (g) off-specular reciprocal space mapping around STO(103) of [SCO_{PC}(~ 24nm)/SCO_{BM} (~ 2nm)] bi-layer, with (e, f and g) indicating an epitaxial and sharp interface beteween SCO_{PC} and SCO_{BM} layer. Right panel (a) Temperature dependent zero field cooled and field cooled magnetization, (b)*M*(H) loop at 5 K after zero field cooling from room temperature **(**the inset shows the enlarged view of *M*(H) loop indicating symmetric coercive field on positive and negative field-axis) (c)*M*(H) loops at 5K after field-cooling from 350 K in a +3 T field (dark yellow circles) and in a +3 T field (orange circles) indicating MEBE effect (d) schematic representation of two possible growth structures (random mixture of Ferro and Antiferro clusters and a well-defined interface between ferromagnetic and antiferromagnetic layers. (e) the thermo-remnant magnetization of [SCO_{PC} (~ 24nm)/SCO_{BM} (~ 2nm)] bi-layer ruling out the possibility for the existence of Ferro and Antiferro clusters.

(d) Dimensional induced metal-insulator transition and WAL-WL crossover in $CaCu_3Ru_4O_{12}$ thin films

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 (for example CeSn). Those systems are conventionally known as heavy-fermionic systems, and show a rich variety of phenomena such as the coexistence of superconductivity and ferromagnetism. The f-electrons, which are localized at high temperatures, hybridize with the conduction electrons at low temperatures through Kondo interaction, thereby forming a very narrow conduction band and, therefore the QP effective mass of the narrow band is substantially enhanced. In the case of d-electron metals, it is not that obvious to identify the same kind of physics. Interestingly certain "d" transition metal oxides such as LiV_2O_4 and $CaCu_3Ru_4O_{12}$ are reported to exhibit remarkable heavy-fermion electronic character, and these systems are under investigation to unveil the microscopic underlying physics. The formation of heavy QP in d-electron system opens a new way to understand the heavy-fermion related physics beyond f-electron systems. Generally, in low spatial dimensions, many-body correlation effects become more prominent and complex. Moreover, both thermal and quantum

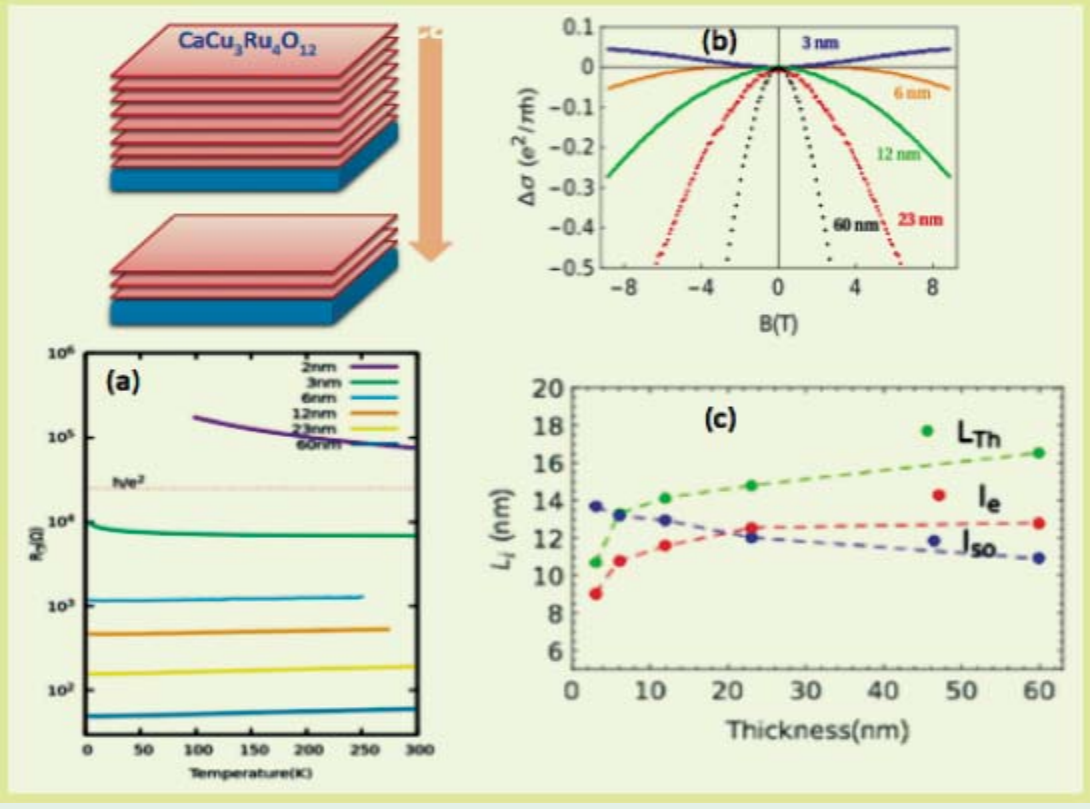


Fig.: Sheet Resistance *vs* temperature showing MIT (b) WAL-WL crossover and (c) extracted length scales (L_{TH},

fluctuations are largely enhanced with a reduction in dimensionality. If heavy fermionic systems can be made 2D, even more fascinating phenomena are expected to result, and such studies are very much desirable. We have put our efforts to fabricate epitaxial $CaCu_3Ru_4O_{12}$ (CCRO) thin films by PLD and to study its dimensional effect by varying thickness. We observe a thickness driven metal insulator transition (MIT) below 3 nm and also a strong inter-play close to MI transition among elastic, inelastic (Thoules) and spin-orbit scattering lengths (L_{TH}, *l*e, *l*so) that gives rise to WAL to WL crossover. Using general 2D magneto transport theory (given by HNL equation) we present plausible physical explanation for WAL-WL crossover.

Reference: *Dimensional induced metal-insulator transition and WAL-WL crossover in $CaCu_3Ru_4O_{12}$ thin films*

Subhadip Jana, BC Behera, Shwetha G Bhat, PS Anil Kumar, **D Samal** (*Manuscript under preparation*)

(e) Towards arresting the possible co-operative Jahn-Teller effect in $Ni_{1-x}Cu_xO$

The structure of bulk CuO as found in nature is unique and at variance with other 3d transition-metal monoxides (TMMOs). While MnO, FeO, CoO, and NiO all crystalize in the rock-salt crystal, CuO crystalizes itself in a non-centrosymmetric monoclinic structure possibly due to strong Jahn-Teller distortion. To arrest such co-operative Jahn-Teller distortion at Cu site and investigate about the local structure, we diluted NiO with Cu to form $Ni_{1-x}Cu_xO$. We observe that Cu substitutes the Ni up to x= 20%. Higher concentration of Cu leads to phase separation. Interestingly, the rocksalt structure is retained upto 20% from XRD investigation. Though XRD gives an average rocksalt- type structure, we are more interested to look for the local structure surrounding Cu-ion in $Ni_{1-x}Cu_xO$ using EXAFS oscillation. The EXAFS oscillation of $Ni_{1-x}Cu_xO$ is quite similar to NiO oscillation and they hardly match with CuO or Cu-metal, which indicate that the monoclinic distortion is reduced. However, detailed EXAFS analysis is being carried out on $Ni_{1-x}CuxO$ along with theoretical modelling to understand the underlying microscopic scenario.

Reference: B. Behera, Subhadip Jana, G K Pradhan S. N. Sarangi, D Swain, **D Samal** (*Manuscript under preparation*)

(f) Unravelling the Complex Magnetic Structure and related thermodynamic Properties in Semiconducting Mn_2SnS_4

Mn_2SnS_4, a ternary chalcogenide with orthorhombic structure, contains chains of isolated edge shared SnS_6 polyhedra along *c*-axis and layers of edge shared MnS_6 polyhedra in *ac*-plane, which are further corner-shared along *b*-direction to form 3D network. Here we investigate the magnetic, thermodynamic and electronic property of Mn_2SnS_4. Magnetic measurements reveal two distinct magnetic transitions: (i) an antiferromagnetic ordering below 155 K (ii) a weak ferromagnetic ordering, possibly due to spin canting and frustration below 53 K. Though the high temperature magnetic transition is well captured in the specific heat measurement, the low temperature one was barely discernible. Refinement of low temperature neutron data suggest that the magnetic moments (spins) within {111} planes are

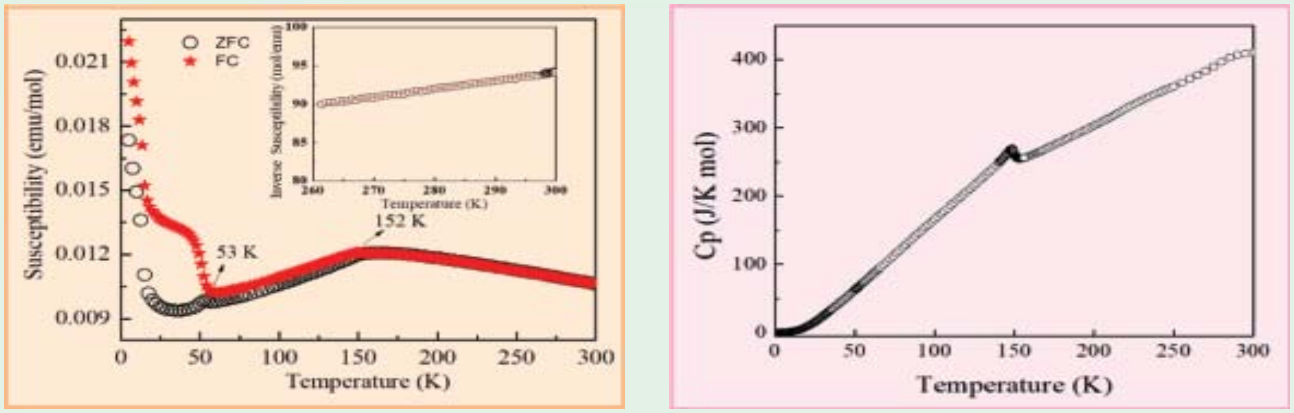


Fig.: Left: Temperature dependent magnetic response showing two distinct magnetic transition. Inset shows the Curie-Weiss fitting of the inverse susceptibility plot in the temperature range of 240 K–300 K with a negative Weiss constant, a signature for antiferromagnetic interaction. We suggest that the transition around 155 K is for ordered antiferromagnetic state and the transition around 53 K is could arise due to spin canting. Right: Heat capacity *vs* temperature plot showing a clear peak around 152 K which corroborate the magnetic transition as observed from magnetometry measurement.

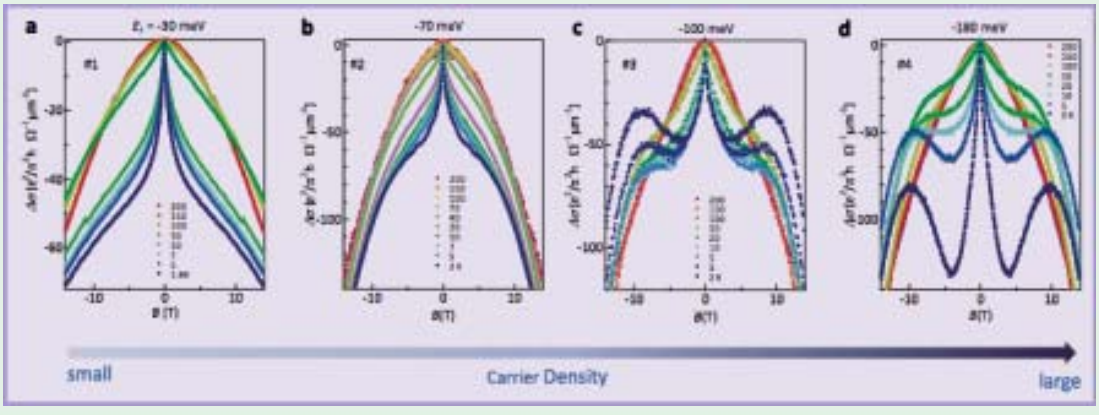
ordered ferromagnetically and the adjacent {111} planes are coupled antiferromagnetically. However, the antiferromagnetic alignment is not collinear rather canted.

Reference: *Unravelling the Complex Magnetic Structure and related thermodynamic Properties in Semiconducting* Mn_2SnS_4

Tuhin S. Dash, Subham Naik, S. D. Kaushik, D Samal, Saroj L.Samal (under review)

(g) Spin-momentum locking in a cubic Dirac material probed by quantum interference

The presence of both inversion (P) and time-reversal (T) symmetries in solids leads to well-known double degeneracy of electronic bands (Kramers degeneracy). The lifting of degeneracy makes spin or chirality to manifest in the form of (pseudo)spin texture in momentum space, such 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. We use quantum interference effects in magnetoconductance to detect hidden



entanglement of spin and momentum in antiperovskite-type 3D Dirac materials. We find robust weak antilocalization (WAL) when the Fermi energy (E_F) is tuned close to the Dirac nodes, whereas clear signature of weak localization (WL) develops when E_F shifts by doping. Notably, the mixing of different Dirac valleys does not suppress WAL, pointing to contrasting interference physics compared to graphene. These results are explained by an axial spin-momentum locking of real spin at each Dirac pocket, which, via scattering among six Dirac valleys that originates from cubic symmetry, effectively rotates spin and restores WAL. The finding points to a novel way to control spin/chirality dynamics by tuning chemical potential and disorder in multi-valley Dirac materials.

Reference: *Spin-momentum locking in a cubic Dirac material probed by quantum interference*

H. Nakamura, J. Merz , E. Khalaf , P. Ostrovsky, A. Yaresko , **D. Samal** , H. Takagi (under Review in Nat. Comm.)

(h) Towards tailoring the electronic properties of rocksalt like CuO by Interface Design

The structure of bulk CuO as found in nature is unique and at variance with other 3d transition-metal monoxides (TMMOs). While MnO, FeO, CoO, and NiO all crystalize in the rock-salt crystal, CuO crystalizes itself in a non-centrosymmetric monoclinic structure possibly due to strong Jahn-Teller distortion. However, we have been successful in stabilising rocksalt type ultrathin CuO layer with c/a >1 using thin film epitaxy. Earlier, we investigated in detail the magnetic character of such ultrathin CuO layer. It is believed that rocksalt type CuO will be a proxy structure for high-T_c superconductivity in 3D upon suitable doping. Keeping in view of the

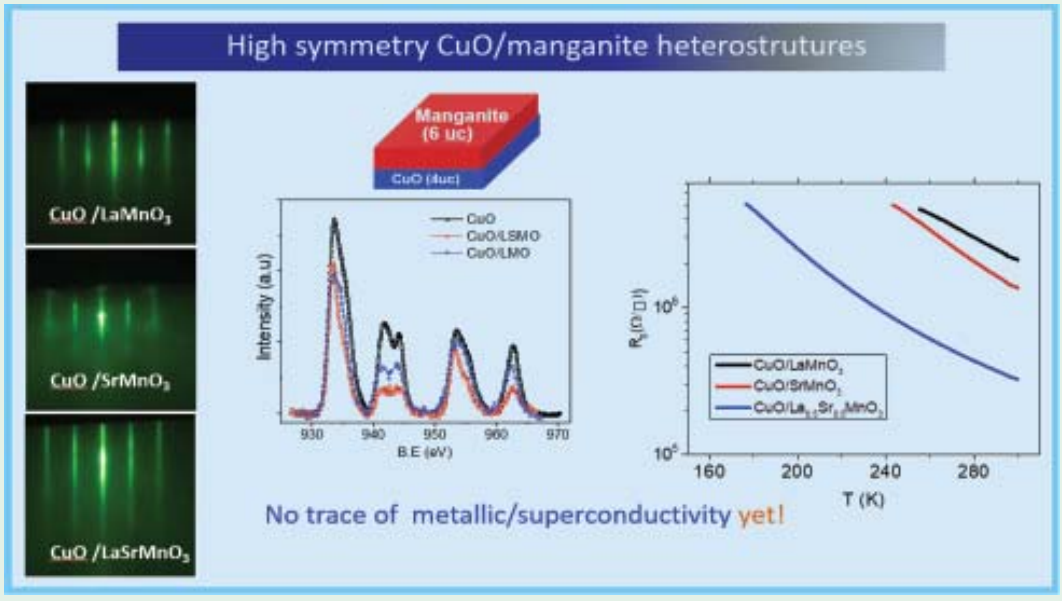


Fig.: Left: RHEED diffraction image for CuO (4 uc)/ manganite (6 uc) indicating a 2D growth pattern. Middle: the Cu 2*p* core-level XPS spectrum indicating Cu^{2+} state in CuO, though the satellite peak intensity seems to diminish with manganite interfacing (a careful analysis is being carried out). Right: Sheet Resistance *vs* temperature for various CuO / manganite heterostructure exhibiting insulating trend. *(Fig. of Sec.-h)*

above, we have fabricated high symmetry CuO/ Manganite heterostructures with unit cell (uc) precision to search for possible interfacial doping effects (assuming charge transfer can happen from manganite to CuO) that could induce metallic/superconducting state in CuO. The Figure below sketches some of our research effort in this direction, though we are not successful yet in driving the CuO towards metallic/ superconducting state.

(This work was carried out during my visit to MPI Stuttgart in the year 2018, as a part of Max Planck Partner Group programme)

(i) Tailoring the magnetic properties of CoV_2O_4 thin films (work in progress)

We are exploring the emergence of second magnetic transition in CoV_2O_4 thin films and its variation subjected to lattice strain, and dimensionality. Below we show a representative magnetic data as a function of magnetic field. In addition to ferromagnetic transition (150K) as observed in bulk case, we observe an additional magnetic transition as marked by arrows towards low temperature side and it disappears with the application of higher magnetic field. Strikingly the hysteresis also exhibits two-step behavior. A detailed study with varying lattice strain, and dimensionality are in progress to delve into the microscopic understanding for the emergence of low temperature magnetic transition as well as the local electronic structure subjected to strain and dimensionality of CoV_2O_4 thin films.

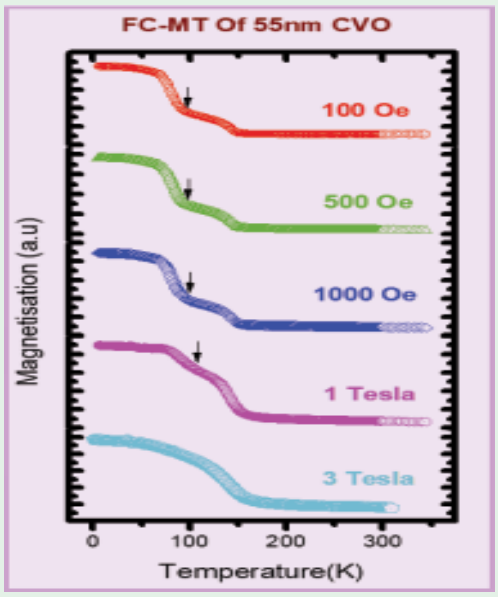


Fig: Temperature dependent magnetisation for CoV_2O_4 thin films on $SrTiO_3$

15. Liquid Crystal Experiments

Duality of defects in isotropic-nematic phase transition in liquid crystals, and looking for Textures in these transitions

We are pursuing our earlier study of duality between point defects in 2-D and line defects in 3-D which we observed in isotropic to nematic transition with a crossed polarizer setup. We are also carrying out numerical simulation of this duality and our results are in confirmation with our experimental results. We are planning a setup to extend it to string to domain wall duality using isotropic-nematic transition in the presence of electric field. We also investigate techniques to identify texture topological objects in these transitions.

(S.S. Dave and A. 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, S. M. Bhattacharjee, G. Tripathy, A. Saha, S. Mandal, D. Chaudhuri)

1. Maxwell's Demon, Szilard Engine and Landauer Principle

The second law of thermodynamics is probabilistic in nature. Its formulation requires that the state of a system be described by a probability distribution. A natural question, thereby, arises as to whether a prior knowledge about the state of the system affects the second law. This question has now been nurtured over a century and its inception was done by C. Maxwell through his famous thought experiment where in comes the idea of Maxwell's demon. The next important step in this direction was provided by L. Szilard who demonstrated a theoretical model for an information engine incorporating Maxwell's demon. The final step that lead to the inter-linkage between information theory and thermodynamics was through Landauer's principle of information erasure that established the fact that information is physical. Here we will present an overview of these three major works that laid the foundations of information thermodynamics.

(P. S. Pal, A. M. Jayannavar)

2. A Brief history of magnetism

In this article an overview of the historical development of the key ideas in the field of magnetism is presented. The presentation is semi-technical in nature. Starting by noting down important contribution of Greeks, William Gilbert, Coulomb, Poisson, Oersted, Ampere, Faraday, Maxwell, and Pierre Curie, we review early 20th century investigations by Paul Langevin and Pierre Weiss. The Langevin theory of paramagnetism and the Weiss theory of ferromagnetism were partly successful and real understanding of magnetism came with the advent of quantum mechanics. Van Vleck was the pioneer in applying quantum mechanics to the problem of magnetism and we discuss his main contributions: (1) his detailed quantum statistical mechanical study of magnetism of real gases; (2) his pointing out the importance of the cristal fields or ligand fields in the magnetic behavior of iron group salts (the ligand field theory); and (3) his many contributions to the elucidation of exchange interactions in d electron metals. Next, the pioneering contributions (but lesser known) of Dorfman are discussed. Then, in chronological order, the key contributions of Pauli, Heisenberg, and Landau are presented. Finally, we discuss a modern topic of quantum spin liquids.

(Navinder Singh, Arun M. Jayannavar)

3. The many avatars of Curzon-Ahlborn efficiency

Efficiency at maximum power output of irreversible heat engines has attracted a lot of interest in recent years. We discuss the occurance of a particularly simple and elegant formula for this efficiency in various different models. The so-called Curzon-Ahlborn efficiency is given by the square-root formula: $1-\sqrt{(Tc/Th)}$, where Tc and Th are the cold and hot reservoir temperatures.

(Ramandeep S. Johal, Arun M. Jayannavar)

4. Storage of electrical energy: Batteries and Supercapacitors

In this article we shall discuss the development of electrical storage system. Since the early days of electricity people have tried various methods to store electricity. One of the

earliest device was a simple electrostatic capacitor that could store less than a micro Joule of energy. The battery has been the most popular in storing electricity as it has a higher energy density. We will discuss the development of batteries and their working principle. Although capacitors has never been thought of as a practical device for electricity storage, in the recent years there has been tremendous progress in building capacitors with huge capacitance and it may soon be possible to use it as storage device. We shall discuss the technological breakthroug in supercapacitor as a storage device.

(Trilochan Bagarti, Arun M Jayannavar)

5. Weyl Semimetals: Down the Discovery of Topological Phases

Recently discovered Weyl semimetals (a semimetal is characterized with an electronic band structure featuring faint connection between conduction band and valence band) are Dirac materials where the gapless Weyl nodes carry with themselves well defined chiralities. Their exhibition of Weyl fermions with topological protection of these so-called magnetic charges immediately turns out to be a head-turning phenomenon due to the realization of singularities in the Berry curvatures (treat them as a kind of magnetic field for now) of the Bloch bands. In this review, we undergo a concise journey from graphene based Dirac physics to Weyl semimetals: the underlying Hamiltonians, their basic features and their unique response to external electric and magnetic fields. We also briefly outline the uniqueness of the Weyl semimetals including possible applications in recent condensed matter experiments.

(Satyaki Kar, Arun M Jayannavar)

6. Current Trends in Quantum Optics

Here we review some of the recent developments in Quantum Optics. After a brief introduction to the historical development of the subject, we discuss some of the modern aspects of quantum optics including atom field interactions, quantum state engineering, metamaterials and plasmonics, optomechanical systems, PT (Parity-Time) symmetry in quantum optics as well as quasi-probability distributions and quantum state tomography. Further, the recent developments in topological photonics is briefly discussed. The potent role of the subject in the development of our understanding of quantum physics and modern technologies is brought out.

(Subhashish Banerjee, Arun Jayannavar)

7. The totally asymmetric simple exclusion process along with particle adsorption and evaporation kinetics is a model of boundary-induced nonequilibrium phase transition. In the continuum limit, the average particle density across the system is described by a singular differential equation involving multiple scales which lead to the formation of boundary layers (BL) or shocks. A renormalization group analysis is developed here by using the location and the width of the BL as the renormalization parameters. It not only allows us to cure the large distance divergences in the perturbative solution for the BL but also generates, from the BL solution, an analytical form for the global density profile. The predicted scaling form is checked against numerical solutions forfinite systems.

(S. M. Bhattacharjee, Sutapa Mukherji, CFTRI, Mysore)

8. Another research work explores the use of a cumulant method to determine the zeros of partition functions for continuous phase transitions. Unlike a first-order transition, with a uniform density of zeros near the transition point, a continuous transition is expected to show a power law dependence of the density with a nontrivial slope for the line of zeros. Different types of models and methods of generating cumulants are used as a testing ground for the method. These include exactly solvable DNA melting problem on hierarchical lattices, heterogeneous DNA melting with randomness in sequence, Monte Carlo simulations for the well-known square lattice Ising model. The method is applicable for closest zeros near the imaginary axis, as these are needed for dynamical quantum phase transitions. In all cases, the method is found to provide the basic information about the transition, and most importantly, avoids root finding methods.

(S. M. Bhattacharjee, Debjyoti Majumdar)

9. Formation of topological vortices during superfluid transition in a rotating vessel

Formation of topological defects during symmetry breaking phase transitions via the *Kibble mechanism* is extensively used in systems ranging from condensed matter physics to the early stages of the universe. Kibble mechanism uses topological arguments and predicts equal probabilities for the formation of defects and anti-defects. Certain situations, however, require a net bias in the production of defects (or anti defects) during the transition, for example, superfluid transition in a rotating vessel, or flux tubes formation in a superconducting transition in the presence of external magnetic field. In this paper we present a modied Kibble mechanism for a specific system, superfluid transition for ^{4}He, which can produce the required bias of vortices over antivortices. Our results make distinctive predictions which can be tested in super fluid ^{4}He experiments. These results have important implications for super fluid phase transitions in rotating neutron stars and also for any super fluid phases of QCD arising in the non-central low energy heavy-ion collision experiment.

(S. S. Dave and A. M. Srivastava)

10. Rheology of active colloids.

We study the steady state and dynamics of soft active colloids. The rheological properties of the system shown interesting time dependent behavior. Through using computational tools we try to understand the observed experimental data of viscoelastic measurements made on solutions of live bacteria. It is conjectured that the active nature of the bacteria along with interaction with polymers plays a role in determining the steady state and dynamical behavior of such systems.

(G Tripathy and collaborators)

11. Driven conductance of an irradiated semi-Dirac material

Transport properties of externally irradiated Dirac materials is a modern area of research in quantum condensed matter physics. In this direction, we theoretically investigate the electronic and transport properties of a semi-Dirac material under the influence of an external time-dependent periodic driving field (irradiation) by means of Floquet theory. We explore the inelastic scattering mechanism between different sidebands, induced by irradiation, by using the Floquet scattering matrix

approach. The scattering probabilities between the two nearest sidebands depend monotonically on the strength of the amplitude of the irradiation. The external irradiation induces a gap in the band dispersion which is strongly dependent on the angular orientation of momentum.

Although the high-frequency limit indicates that the gap opening does not occur in an irradiated semi-Dirac material, a careful analysis of the full band structure beyond this limit reveals that a gap opening indeed appears for higher values of momentum (away from the Dirac point). Furthermore, the angular-dependent dynamical gap is also present and cannot be captured within the high-frequency approximation. The contrasting features of an irradiated semi-Dirac material, in comparison with irradiated graphene, can be probed via the behavior of conductance. The latter exhibits the appearance of nonzero conductance dips due to the gap opening in the Floquet band spectrum. Moreover, by considering a nanoribbon geometry of such a material, we also show that it can host a pair of edge modes which are fully decoupled from the bulk, which is in contrast to the case of a graphene nanoribbon where the edge modes are coupled to the bulk. We also investigate whether, if the nanoribbon of this material is exposed to the external irradiation, decoupled edge modes penetrate into the bulk features of an irradiated semi-Dirac material, in comparison with irradiated graphene, can be probed via the behavior of conductance. The latter exhibits the appearance of nonzero conductance dips due to the gap opening in the Floquet band spectrum. Moreover, by considering a nanoribbon geometry of such a material, we also show that it can host a pair of edge modes which are fully decoupled from the bulk, which is in contrast to the case of a graphene nanoribbon where the edge modes are coupled to the bulk. We also investigate whether, if the nanoribbon of this material is exposed to the external irradiation, decoupled edge modes penetrate into the bulk.

(S. K. Firoz Islam, Arijit Saha)

12. Probing the tilted Dirac cones via RKKY exchange interaction in anisotropic Dirac materials

In this work, we theoretically investigate the indirect signatures of the tilted anisotropic Dirac cones on Ruderman-Kittel-Kasuya-Yosida (RKKY) exchange interaction in a two-dimensional polymorph of boron atoms. Unlike the case of isotropic non-tilted Dirac material-graphene, here we observe that the tilting of the Dirac cones exhibits a significant impact on the RKKY exchange interaction in terms of the suppression of oscillation frequency. The reason can be attributed to the behavior of the Fermi level and the corresponding density of states with respect to the tilting parameter. The direct measurement of the period of the RKKY interaction can thus be a possible probe of the tilt parameter associated with the tilted Dirac cones. We also obtain the direction dependent analytical expressions of the RKKY exchange interaction, in terms of Meijer G-function. However, the effects due to tilting of the Dirac cones on the RKKY interaction depend on the spatial alignments of the two magnetic impurities with respect to the direction of tilting.

(Ganesh C. Paul, SK Firoz Islam, Arijit Saha)

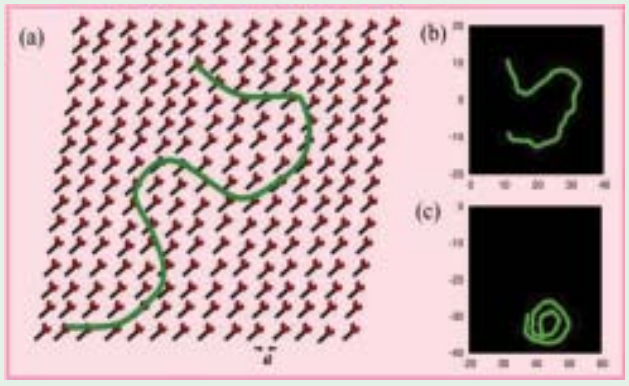
13. We investigate magnetic properties of various MnO2 materials. The defect production for quench dynamics is investigated for model systems. Materials with hydrogen bonding is also investigated. Topological properties of higher dimensional model system is looked in. Entanglement properties of superconducting pairs are investigated.

Working on the properties of material H2SQ concentrating on different phases at zero temperature as well as finite temperature. Investigating magnetic properties of alpha-MnO2 material. Looking into topological properties of extended Haldane model and Iron-pnictides high temperature superconductivity.

(S. Mandal)

14. Active filaments:

Using theoretical modeling and numerical simulations, we have studied morphological and dynamical transitions of semiflexible bio-polymers under the influence of the gliding assay of molecular motors. The activity of such an assay can be controlled, e.g., by changing the ambient ATP concentration. Attached motor proteins move along the filament to one of its ends with a velocity that varies nonlinearly with the motor protein extension. The motor proteins attach to and detach from filament segments stochastically, with a detachment rate that depends on the local load experienced. The resultant force on the filament drives it out of equilibrium. The distance from equilibrium is reflected in the end-to- end distribution, modified bending stiffness, and a transition to spiral morphology of the polymer. The local stress dependence of activity results incorrelated fluctuations in the speed and direction of the center of mass leading to a series of ballistic-diffusive crossovers in its dynamics. The work is being done in collaboration with Abhishek Chaudhuri of IISER-Mohali. A part of the results have been published recently in Phys. Rev. E. (*Phys. Rev. E.* **99**, 042405 (2019)).



(Dr. D. Chaudhuri)

15. Chromosomal organization in bacteria:

In this collaborative project we have been working on with the aim of understanding physical forces and mechanisms behind dynamic and structured organization of chromosome in bacteria, arguably the simplest form of living cells. In the theoretical front, we have proposed a polymer-based model of chromosome. Our modeling approach is finding wide recognition. We have been invited to contribute a chapter on our modeling approach in the book on "bacterial chromatin" in Springer protocol series. In a multi-institutional and multi-continental collaboration, we developed a simple structured-polymer model from the available microscopic information, and test our predictions against observed properties of live bacteria. In particular, our collaborators in the Netherlands and the USA obtained detailed structural information of E.coli chromosome. We found spectacular organizational behavior that could be described

completely in terms of our polymer-based modeling of chromosome taking care of the cytosolic crowding in terms of an entropic depletion interaction. The crowders compress the chromosome to produce their signature helicoid structure. In particular, we could successfully predict the observed non-linear growth of chromosomal size with cell length, central positioning of chromosomes, and chromosomal segregation in dividing cells in terms of protein production around chromosomes following transcription and translation.

Our theoretical modeling along with experimental approach provided a solution to the decades old problem of observed chromosomal segregation in E.coli in absence of dedicated machinery. A part of the simulations and analysis

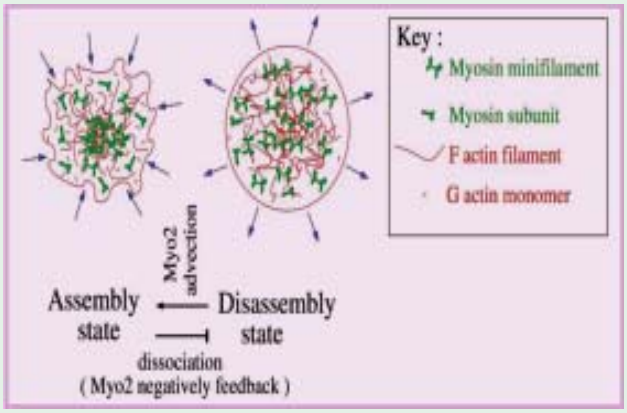
performed by my PhD student Pinaki Swain of IIT-Hyderabad has been published in *Soft Matter*, **15**(12), 2677–2687 (2019). Another part of this work, accompanied by experiments on live E.coli done by our collaborators has been accepted for publication in a highly respected biology journal, *Current Biology*.

Along with another PhD student, Amit Kumar, I have been performing a detailed theoretical modeling and analysis on microscopic organization of chromosome considering interaction between the DNA and associated proteins. We have written a paper on a part of this study, and the paper has been submitted for publication (arXiv:1811.08172).

(Dr. D. Chaudhuri)

16. Active matter:

The third area of our current interest is physics of active matter. In this we have taken a two-pronged approach – (a) studying phase behavior of new active material using particle based model and simulations, (b) using field theoretic approach to model large scale properties and pattern formation. The studies of active matter has two goals – identifying new emergent properties which may help designing new smart material, the other being understanding of biologically relevant systems that potentially help in the first goal, as well help us develop new insight into natural phenomena. With my PhD student, Amir Shee we have been studying a coarse grained model of cytoskeleton using hydrodynamic approach. This shows that in presence of strain dependent turnover, the cortical cytoskeleton may potentially show three behaviors. It may remain homogeneous, may sustain steady state patterns, most interestingly

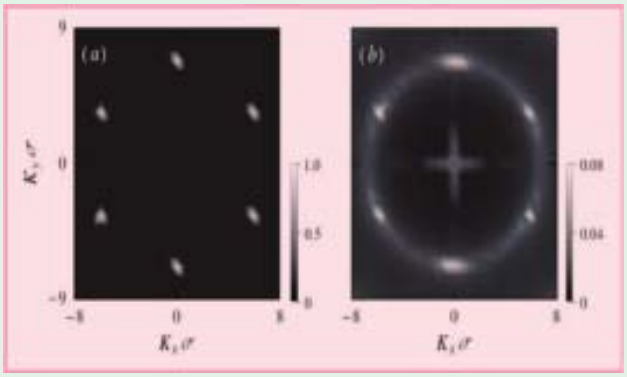


it as well show pulsatory propagation depending on activity and turnover. Currently, we are writing up parts of these studies for publication. With a postdoctoral fellow working in my group, Dr. Biplab Bhattacharjee, we have been studying non-equilibrium phase transitions in active polar particles aligning in a nematic way. The system shows a continuous transition between isotropic and nematic fluid, and a first order phase separation between nematic fluid and hexatic clusters with change in aligning strength and activity. We are writing up an article summarizing a part of the findings in this project.

(Dr. D. Chaudhuri)

17. Phase transition in soft and driven matter:

In this project, we have been studying structural transitions in driven colloids. We considered a sterically stabilized colloidal solid under flashing ratchet potential driving directed current through the system. With changing frequency of stochastic ratcheting, we found a



resonance in the directed current produced at the many-body relaxation frequency, which in turn is controlled by the ambient density of particles. Near the resonance frequency the solid melts into hexatic, showing phase separationcharacteristic of a first order transition. We obtained the full phase diagram in the frequency-density plane. The generation of current carrying channels leads to this defect (disclination) – mediated melting. This work in this project is being carried out in Collaboration Dipanjan Chakraborty of IISER- - Mohali.

(Dr. D. Chaudhuri)

PUBLICATIONS

3.1. Papers Published in Refereed Journals

1. ***Stochastic Heat Engine Powered By Active Dissipation.***
Saha, Arnab, Marathe, Rahul; Pal, P.,S.,and Jayannavar, A. M.
J. Stat. Mech. (2018)113203.

2. **Global Density Profile For Particle Non-Conserving One Dimensional Transport From Renormalization Group Flows**
SutapaMukherji and S. M. Bhattacharjee, Scientific Reports volume 9, Article number: 5697(2019)

3. ***Pulsars as Weber gravitational wave detectors",***
Arpan Das,Shreyansh S. Dave, OindrilaGangulyandAjit M. Srivastava
ArXiv:1804.00453, Phys. Lett. B 791 (2019) 167.

4. **Formation of Anisotropic Nanostructures on Rutile TiO2(110) Surfaces and Their Photo-Absorption Properties,**
Vanaraj Solanki, Shalik R. Joshi, Indrani Mishra, D. Kanjilal and Shikha Varma,
Metallurgical and Materials Transactions 49A (2018) 3117.

5. **Investigation of Optical, Electrical and Magnetic Properties of hexagonal NiTiO3Nanoparticles Prepared via Ultrasonic Dispersion Techniques for high power applications,**
SubrataKaramkar, Ashis Manna, Shikha Varma, and D. Behera,
Material Research Express 5 (2018) 055037.

6. ***Investigation of structural and electrical transport properties of Nano-flower shapedNiCo2O4 supercapacitor electrode materials,***
SubrataKaramkar, Ashis Manna, ShikhaVarma, and D. Behera,
Journal of Alloys and Compounds 757 (2018) 49.

7. **Topographic Evolution and Scaling Study of ZnO (0001) Single Crystal After Low-Energy Atom Beam Irradiation,**
Vanaraj Solanki, D. Kabiraj, D. K. Avasthi, ShikhaVarma,
Nucl. Instru. Meth. B 434 (2018) 56.

8. ***Anisotropic super-paramagnetism in cobalt implanted rutile-TiO2 single Crystals,***
S. R. Joshi, B. Padmanabhan, A. Chanda, N. Shukla, V.K. Malik, D. Kanjilal,
and ShikhaVarma, Jour. of Magnetism and Magnetic Materials 465 (2018) 122.

9. ***A Study on Optical and Dielectric Properties of Ni-ZnOnanocomposite,***
S. Karamankar, B. Panda, B. Saho, K. L. Routray, S.Varma, D. Behera,
Materials Science in Semconductor Processing 88 (2018) 198.

10. ***The effect of Ti+ ion implantation on the Anatase- Rutile Phase Transformation andResistive Switching properties of TiO2 thin films***

Ashis Manna, A. Barman, ShalikR.Joshi, B. Satpati, P. Dash, AnanyaChattaraj, S.K. Srivastava, P.K.Sahoo, A. Kanjilal,D. Kanjilal and Shikha Varma,

Jour. Appl. Physics 124 (2018) 155303.

11. **Electronic structure of Pr2MnNiO6 from x-ray photoemission, absorption and densityfunctional theory,**

B. Padmanabhan, Shalik Joshi; Yadav, Ruchika Yadav, Frank deGroot, Amit Singh, Ray, AvijeetRay, Mukul Gupta, Ankita Singh Maurya, SatyendraMaurya, Suja Elizabeth, Shikha Varma, TulikaMaitra, and Vivek K. Malik,

Journal ofPhysics condensed Matter 30 (2018) 435603.

12. **Investigation on Structural, Morphological and Optical Properties of Co-doped ZnOThin Films,**

Prashant Shukla, Shristi Tiwari, Shalik Ram Joshi, V. R. Akshya, M.Vasundhara, Shikha Varma, Jai Singh and AnupamaChanda, Physica B 550 (2018)303.

13. **Distinguishing different classes of entanglement of three-qubit pure states in an experimentally implementable way,**

SatyabrataAdhikari, ChandanDatta, Arpan Das, and PankajAgrawal,

Eur. Phys. J. D (2018) 72:157.

14. **Coherence of quantum channels,**

ChandanDatta, SkSazim, ArunPati and PankajAgrawal,

Annals of Phys 397 (2018) 243.

15. **Probing the Type-II Seesaw Mechanism through the Production of Higgs Bosons at a Lepton Collider,**

Pankaj Agrawal, ManimalaMitra, SaurabhNiyogi, SujayShil, andMichael Spannowsky,

Phys Rev D 98, 015024 (2018).

16. **Two-qubit mixed states and teleportation fidelity: Purity, concurrence, and beyond,**

Sumit Nandi, ChandanDatta, Arpan Das,and Pankaj Agrawal,

Eur. Phys. J. D (2018) 72:182.

17. **Mutual Uncertainty, Conditional Uncertainty and Strong Sub-Additivity,**

SkSazim, SatyabrataAdhikari, ArunPati and Pankaj Agrawal,

Phys Rev A 98, 032123 (2018).

18. **Optical Band Gap, Local Work Function and Field Emission Properties of MBE Grown â-MoO3 Nanoribbons**
P. Maiti, P. Guha, R.Singh, J.K. Dash, and P.V. Satyam
Applied Surface Science **476** (2019) 691- 700

19. **Microscopy and Spectroscopy Study of Nano structural Phase Transformation from â-MoO3 to Mo under UHV–MBE Conditions**
P. Maiti, P. Guha, H. Hussain, R. Singh, C. Nicklin, and P.V. Satyam
Surface Science **682** (2019) 64 - 74

20. **In Situ/ex Situ Investigations on the Formation of the Mosaic Solid Electrolyte Interface Layer on Graphite Anode for Lithium-Ion Batteries**
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ALICE Publication:

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2. **Event-shape engineering for the D-meson elliptic flow in mid-central Pb-Pb collisions at 5.02 TeV;**
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3. **Azimuthal anisotropy of heavy-flavor decay electrons in p-Pb collisions at 5.02 TeV;**
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4. **Measurement of dielectron production in central Pb-Pb collisions at 2.76 TeV;**
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5. **p-p, p-Λ and Λ-Λ correlations studied via femtoscopy in pp reactions at 7 TeV;**
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6. **Multiplicity dependence of light-flavor hadron production in pp collisions at 7 TeV;**
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7. **Suppression of Ë(1520)resonance production in central Pb-Pb collisions at 2.76 TeV;**
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8. **Dielectron and heavy-quark production in inelastic and high-multiplicity proton-proton collisions at 13 TeV;**
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14. **Measuring K0S K± interactions using pp collisions at s″=7 TeV;**
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17. **Medium modification of the shape of small-radius jets in central Pb-Pb collisions at 2.76TeV;**
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18. **Neutral pion and ç meson production at mid-rapidity in Pb-Pb collisions at 2.76 TeV;** Phys. Rev. C 98, 044901 (2018)

19. **Dielectron production in proton-proton collisions at 7 TeV;** JHEP 1809 (2018) 064

20. **Azimuthally-differential pion femtoscopy relative to the third harmonic event plane in Pb-Pb collisions at 2.76 TeV;** Phys. Lett. B 785 (2018) 320

21. **Anisotropic flow of identified particles in Pb-Pb collisions at 5.02 TeV;** JHEP09 (2018) 006

22. **Inclusive J/ø production in Xe-Xe collisions at 5.44 TeV;** Phys. Lett. B 785 (2018) 419-428

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25. **Inclusive J/ø production at forward and backward rapidity in p-Pb collisions at 8.16 TeV;** JHEP 07 (2018) 160

26. **Energy dependence and fluctuations of anisotropic flow in Pb-Pb collisions at 5.02 and 2.76** TeV; JHEP 07 (2018) 103

27. **φ meson production at forward rapidity in Pb-Pb collisions at 2.76 TeV;** Eur. Phys. J. C 78 (2018) 559

28. **Measurement of the inclusive J/ø polarization at forward rapidity in pp collisions at 8 TeV;** Eur. Phys. J. C 78 (2018) 562

29. **Constraints on jet quenching in p-Pb collisions at 5.02 TeV measured by the event-activity dependence of semi-inclusive hadron-jet distributions;** Phys. Lett. B 783 (2018) 95-113

30. **Prompt and non-prompt J/ø production and nuclear modification at mid-rapidity in p-Pb collisions at 5.02 TeV;** Eur. Phys. J. C 78 (2018) 466

31. **Ë+c production in pp collisions at 7 TeV and in p-Pb collisions at 5.02 TeV**;
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32. **First measurement of Î0c production in pp collisions at 7 TeV;**
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33. **Longitudinal asymmetry and its effect on pseudorapidity distributions in Pb-Pb collisions at 2.76 TeV;**
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STAR Publication: J. Adam, *et al*... P. K. Sahu. *et al.* (STAR Collaboration)

1. **Low pTe+e- Pair Production in Au+Au Collisions at 200 GeV and U+U Collisions at 193 GeV at STAR;**
Phys. Rev. Lett. 121 (2018) 132301

2. **Harmonic decomposition of three-particle azimuthal correlations at RHIC**;
Phys. Rev. C 98 (2018) 34918

3. **Collision Energy Dependence of Moments of Net-Kaon Multiplicity Distributions at RHIC**;
Phys. Lett. B 785 (2018) 551

4. **J/psi production cross section and its dependence on charged-particle multiplicity in p+p collisions at 200 GeV**;
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5. **Erratum: Observation of D0 meson nuclear modifications in Au+Au collisions at 200 GeV**;
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6. **Transverse spin transfer to Lambda and anti-Lambda hyperons in polarized proton-proton collisions at 200 GeV**;
Phys. Rev. D 98 (2018) 91103

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8. **Constraining the initial conditions and temperature dependent transport with three-particle correlations in Au+Au collisions;**
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9. **The Proton-Omega correlation function in Au+Au collisions at 200 GeV**;
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10. **Measurement of the longitudinal spin asymmetries for weak boson production in proton-proton collisions at 510 GeV;**
Phys. Rev. D 99 (2019) 51102

11. **Centrality and transverse momentum dependence of D0-meson production at mid-rapidity in Au+Au collisions at 200 GeV;**
Phys. Rev. C 99 (2019) 34908

12. **Measurement of hyper triton lifetime in Au+Au collisions at the Relativistic Heavy-Ion Collider;**
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13. **MWPC prototyping and performance test for the STAR inner TPC upgrade; Nucl. Instrum. Meth.**
A 896 (2018) 90

14. **Beam Energy Dependence of Jet-Quenching Effects in Au+Au Collisions at 7.7, 11.5, 14.5, 19.6, 27, 39, and 62.4 GeV;**
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15. **Global polarization of Lambda hyperons in Au+Au collisions at 200 GeV;**
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16. **Azimuthal anisotropy in Cu+Au collisions at 200 GeV;**
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17. **Correlation Measurements between Flow Harmonics in Au+Au Collisions at RHIC;** Phys. Lett. B 783 (2018) 459

18. **Longitudinal Double-Spin Asymmetries for Dijet Production at Intermediate Pseudorapidity in Polarized pp Collisions at 200 GeV;**
Phys. Rev. D 98 (2018) 32011

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Phys. Rev. D 98 (2018) 32013

20. **Beam energy dependence of rapidity-even dipolar flow in Au+Au collisions;**
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21. **The evolution of the STAR Trigger System;Nucl. Instrum. Meth.**
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3.2. Papers Communicated / Submitted to National/International Refereed Journals

1. **Maxwell's Demon, Szilard Engine and Landauer Principle.**
Pal, P. S.; and Jayannavar, A. M.
ArXiv:1904.05256.

2. **A Brief history of magnetism.**
Singh, Navinder; and Jayannavar, A. M.
ArXiv: 1903.07031.

3. **The many avatars of Curzon-Ahlborn efficiency.**
Johal, Ramandeep S.; and Jayannavar, A. M.
ArXiv:1903.04381.

4. **Storage of electrical energy: Batteries and Supercapacitors.**
Bagarti, Trilochan; and Jayannavar, A.M.
ArXiv:1903.03740.

5. **Weyl Semimetals: Down the Discovery of Topological Phases.**
Kar, Satyaki; and Jayannavar, A.
M. ArXiv:1902.01620.

6. **Current Trends in Quantum Optics. Banerjee**,
Subhashish; and Jayannavar, A. M.
ArXiv:1902.08576

7. **"Cumulants, Zeros, and Continuous Phase Transition",**
DebjyotiMajumdar and S. M. Bhattacharjee,
ArXiv: 1903.11403

8. **Formation of topological vortices during superuid transition in a rotating vessel",**
Shreyansh S. Dave, and Ajit M. Srivastava,
ArXiv: 1805.09377 (Accepted for publication in Europhysics Letters).

9. **Synthesis and characterization of aligned ZnOnanorods for visible light photocatalysis,**
P. Dash, A. Manna, N.C. Mishra, Shikha Varma, and Physica E:
Low-dimensional Systemsand Nanostructures (in press).

10. **Minimal Scenario Facet Bell inequalities for multi-qubit states**,
Arpan Das, ChandanDatta, and Pankaj Agrawal,
ArXiv preprint arXiv:1809.05727.

11. **Resource state structure for cooperative quantum key distribution**
Arpan Das, Sumit Nandi, SkSazim, and Pankaj Agrawal,
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12. **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
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14. **Field-independent features in the magnetization and specific heat of Sm3Co4Ge13**
Harikrishnan Nair, Ramesh Kumar R, BaidyanathSahu, SindisiweXhakaza, Pramita Mishra, DebkantaSamal, Sarit Ghosh, and Biju Raja Sekhar Andre Strydom. Under consideration in Crystals, 2019

15. **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 (2019) (under review)

16. **A note on Quantum Fields in Conformally at Space-times**
Swayam-sidha Mishra, SudiptaMukherji, and Yogesh K. Srivastava,
ArXiv: 1810.09677,
Submitted for publication

17. **Time dependent backgrounds and Ads/CFT: Radiation dominate**
Universe, with
S. Mishra, Y. Srivastava (NISER)and SudiptaMukherji

18. **Temperature dependent study of neutron-rich thermally fissile $^{244-262}$Th and $^{246-264}$U nuclei within E-TRMF model**
Abdul Quddus, K. C. Naik, R. N. Panda and S. K. Patra,
Nucl. Phys. A (2019) in press.

19. **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. C (2019) in press.

20. **"Experimental and simulation studies on temporal evolution of chemically etched Si** surface: Tunable light trapping and cold cathode electron emission properties"
R. Singh, S. A. Mollick, M. Kumar, M. Saini, P. Guha, and TapobrataSom,
Journal of Applied Physics.

21. "**Influence of grain size on local work function and optoelectronic properties of** n-ZTO/p-Siheterostructures"
Ranveer Singh, Alapan Dutta, Pronoy Nandi, Sanjeev K Srivastava, TapobrataSom,
Applied Surface Science.

22. "**Growth angle-dependent evolution of morphology and magnetic properties of Co films on highly ordered self-organized Ge substrates**"
SafiulAlamMollick, Ranveer Singh, BiswarupSatpati, Satyaranjan Bhattacharyya, and TapobrataSom, Applied Surface Science.

23. "**Optical, photoctalytic and wetting behavior of GLAD N_2-TiO_2 films**"
Rajnarayan De, S. MaidulHaque, J. S. Misal, D. D. Shinde, C. Prathap, S.R. Polaki, Ranveer Singh, TapobrataSom, and K. Divakar Rao,
Physica Status Solidi (a).

24. "**Tunable optoelectronic properties of radio frequency sputter deposited Sb_2Se_3 thin films: Role of growth angle and thickness"**
Alapan Dutta, Ranveer Singh, Sanjeev K Srivastava, andTapobrataSom,
Solar Energy.

25. **Application of Nilsson model for deformed nucleus in relativistic heavy ion collisions;**
S. K. Tripathy, M. Younus, P. K. Sahu and Z. Naik;
ArXiv:1802.00639 (2018) submitted to Journal.

26. **Study of the GEM detectors with proton induced X-ray radiation of different energy Below 10 keV;** submitted to Journal
P. K. Sahu, S. Swain, S. Sahu, A. Tripathy and B. Mallick; (2019),

27. **Study of ion Backflow fraction for GEM based detector Submitted to Journal**
S. Swain, P. K. Sahu, S. Sahu and A. Tripathy; (2019)

28. **Role of orientational ordering of A site cation in electronic structure of hybrid perovskite**
J. Phys. Chem. Let.D.Topwal

29. **Effect of substrate and surface morphologies on the electronic states of stepped films.**
Phys. Rev. B, .D.Topwal

30. **Synthesis of $Fe_{(1-x)}Co_xSi$ cubic B20 structure by dual implantation of 50 keV Fe and Co** in Si under an external magnetic field.
J. App. Phy., .D.Topwal

31. **Defect production and quench dynamics in three-dimensional Kitaev model**
Authors: DibyenduRana, Subhajit Sarkar, and Saptarshi Mandal
ArXiv:1812.09923
Submitted in Phys. Rev. B

32. **The CMS Collaboration, Measurement of the associated production of a Higgs boson with a top quark pair in final states with electrons, muons and hadronically decaying tau leptons in data recorded in 2017 at sqrt(s)= 13 TeV, CMS-PAS-HIG-18-019.**
A.K.Nayak

33. **Cell boundary confinement sets the size and position of the E.col chromosome",**
F. Wu, Pinaki Swain, DC, Bela Mulder, Cees Dekker, DebasishChaudhuri
bioRxiv (2018); doi: 10.1101/348052. [Accepted for publication in Current Biology]

34. **Cross-linker mediated folding and local morphologies in a model chromosome,**
Amit Kumar &DebasishChaudhuri, arXiv:1811.08172 (submitted)

35. **Symmetries of free massless particles and soft theorems :**
Authors: Shamik Banerjee
ArXiv: 1804.06646

36. **Conformal properties of soft operators - 1 : Use of null states :**
Authors: S.Banerjee, P.Paul, and P.Pandey
ArXiv: 1902.02309

37. **Complex magnetic structure and related thermodynamic properties of Mn2SnS4**
T S Dash, S Naik, S. D. Kaushik, D. Samal, Saroj L Samal (under review).

38. **Field-independent features in the magnetization and specific heat of**
Sm3Co4Ge13
H. S. Nair, K. R Kumar, P. Mishra, D. Samal et al. (under review).

39. **Robust weak antilocalization due to spin-orbital entanglement in Dirac material Sr3SnO**
H.Nakamura, J. Merz, E. Khalaf, P. Ostrovsky, A. Yaresko, **D. Samal**, H. Takagi, **arXiv:1806.08712v1** (*Under review in Nature Communications*)

40. **Dominant production of heavier Higgs bosons through vector boson fusion in NMSSM**
(arXiv:1804.06630, Phys.Rev D)(D.Das)

41. **Doubly-charged Higgs Boson at Future Electron-Proton Collider,**
ArXiv:1903.0143 (M.Mitra)

42. **The CLIC Potential for New Physics, arXiv:1812.02093, CERN Yellow Rep. Monogr. Vol. 3(2018)** (M.Mitra)

43. **Fat Jet Signature of a Heavy Neutrino at Lepton Collider,** : arXiv:1810.08970, M.Mitra

3.3. Conference Proceedings

1. **Constraining Non-Standard Interactions of Neutrino Using ICAL Detector at INO**
Amina Khatun, SabyaSachi Chatterjee, TarakThakore, and Sanjib Kumar Agarwalla
Proceedings of the 22nd DAE-BRNS HEP Symposium, University of Delhi, Delhi,India, 12-16 December, 2016Springer Proc.Phys. 203 (2018) 289-292.

2. **Searches for ttH production at CMS, Proceedings of XXVI International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2018), 16-20 April 2018, Kobe, Japan;**
A.K. Nayak [On behalf of the CMS Collaboration]
PoS(DIS2018)065; CMS-CR-2018-076; arXiv:1807.05500[hep-ex].

3. **Characterisation of Metal by GEM Detector using Ion Beam Facility at IOP**
A. Tripathy, P. K Sahu, S. Swain, S. Sahu and B. Mallick,
XXIII DAE-BRNS HIGH ENERGY PHYSICS SYMPOSIUM 2018

4. **Construction of a single GEM detector using indigenous anode plate**
A. Triparty, S. Swain, P.K Sahu, and S. Sahu,
XXIII DAE-BRNS HIGH ENERGY PHYSICS SYMPOSIUM 2018

5. **Measurement of Ion backflow with GEM-based detectors**
S Swain, P. K. Sahu, S. K. Sahu and A. Tripathy,
XXIII DAE-BRNS HIGH ENERGY PHYSICS *SYMPOSIUM* 2018

6. **Enhanced production of multi-strange hadrons in proton-proton collisions**
S. Sahoo, R. C. Baral, P. K. Sahu and M. K. Parida,
XXIII DAE-BRNS HIGH ENERGY PHYSICS *SYMPOSIUM* 2018

7. **Simulation study for signal formation with single GEM detector**
S S Dani, S Swain, P K Sahu and S N Nayak,
XXIII DAE-BRNS HIGH ENERGY PHYSICS *SYMPOSIUM* 2018

3.4 Books

1. "**Molecular dynamics simulations of a feather-boa model of bacterial Chromosome",**
DC & Bela M Mulder,
Book chapter in Bacterial Chromatin edited by Remus T. Dame, Springer (2018). (Book Chapter)

3.5 Papers published by External User

1. "Development of graphene capped silicon–silicon oxide core–shell nano-structure: Charge trapping characteristics at the interfaces"
A. Nandi, S. Biswas, S. Chakrabarty, S. Majumdar, H. Saha, Mahesh Saini, and S. Hossain, Applied materials Today13 (2018) 370.

COLLOQUIA AND SEMINARS

4.1. Colloquia & Popular Talk

4.1.1. Colloquium

Sl. No.	Date	Name and address of Speaker	Title
1	11.04.2018	Prof. Subhendra Mohanty (PRL, Ahmedabad)	Dark Matter in the Universe
2	04.09.2018	Prof. D.D. Sarma IISc, Bangalore	A New Generation of Photovoltaic Materials: Organic-inorganic Hybrid Perovskites
3	07.12.2018	Prof. Bela M. Mulder, Group leader: Theory of Biomolecular Matter, Institute AMOLF, Amsterdam	"Microtubule dynamics: from biology to physics and back"
4	14.12.2018	Professor Mukunda P Das RSPE, The Australian National University, Canberra	Bose, Bosons and Boson Condensation
5	17.01.2019	Prof. Sunanda Banerjee, Fermilab, USA	Collider Experiments and India
6	30..01.2019	Prof. Tanusree Saha Dasgupta, IACS Kolkata	Beyond the conventional DFT: Life with U"

4.2. Seminars

4.2.1. Seminar of General Interest

1	16.07.2018	Dr. Subhash C Yadav AIIMS, New Delhi	Principle, Evolution and Advancement of Electron Microscopy (combined session with WS02)
2	16.07.2018	Dr. Biswarup Satpati SINP, Kolkata.	Transmission Electron Microscopy and associated techniques for characterization of nanomaterials
3	16.08.2018	Surja Kiran Ghorui, S.J.T.Univ., Shanghai, China.	Nuclear Isomers and their implications in the stellar environments
4	17.08.2018	Manpreet Kaur, Sri GGS University, Punjab.	Dynamics of Heavy Ion Collisions at Low and Intermediate Energies
5	24.08.2018	Saumi Dutta Univ. of Calcutta, Kolkata.	Radiative Neutron Capture Relevant to Heavy Element Nucleosynthesis Processes
6	06.09.2018	Dr. Y P Prabhakara Rao IISc, Bangalore	National Nanofabrication Centre: Facilities and collaboration opportunities
7	24.09.2018	Dr. Venkata Sathish Akella IIT Madras	Self-propulsion by Marangoni forces
8	26.10.2018	Dr. Anil K. Sinha RRCAT, Indore	X-ray Synchrotron Radiation Facilities at RRCAT, Indore and their usages
9	15.11.2018	Presentation from Baltic Scientific Instruments	Semiconductor Detectors and Nuclear Electronics From Baltic Scientific Instruments.
10	24.12.2018	Prof. Bir Bikram Singh Sri GGS World University, India	Investigating the fusion enhancement for neutron-rich mid-mass nuclei
11	07.01.2019	Dr. Sandipan Dutta, IBS South Korea	Gene to Protein mapping in a simple mechanical model of protein
12	16.01.2019	Prof. Amitabha Bhattachary, SPS, Sikkim University	Natural Soaps: A Biodegradable Alternative
13	22.03.2019	Dr. Subrata Kumar BiswalInstitute of Theoretical Physics,Chinese Academyof Sciences.	Effects of the φ-meson on the hyperon production in the hyperon star and study of GW170817 by CSKP

4.2.2. Lecture Series

1	12.04.2018	Prof. Sourendu Gupta, TIFR Mumbai	Lecture series on Thermodynamics, phase transitions and elementary particles
2	13.04.2018	Prof. Sourendu Gupta, TIFR Mumbai	Lecture series on Thermodynamics, phase transitions and elementary particles
3	01.10.2018	Prof. Biplob Bhattacherjee CHEP,IISc	Introductory lectures on QCD and collider physics
4	03.10.2018	Prof. Biplob Bhattacherjee CHEP, IISc	Introductory lectures on QCD and collider physics
5	04.10.2018	Prof. Biplob Bhattacherjee CHEP, IISc	Introductory lectures on QCD and collider physics
6	12.12.2018	Professor Mukunda P. Das RSPE, The Australian National University, Canberra, Australia	Anomaly in Quantized Conductance in Quasi-1D Metallic Quantum Wire beyond the Landauer model
7	17.12.2018	Professor Mukunda P Das RSPE, The Australian National University, Canberra, Australia	Anomaly in Quantized Conductance in Quasi-1D Metallic Quantum Wire beyond the Landauer model

4.2.3. Synopsis / Annual Review Talk / Thesis Defence

1	20.04.2018	Mr. Subhadip Ghosh	Active maintenance of structure and transport: Impact of molecular motors
2	30.05.2018	Mr. Arpan Das IOP, Bhubaneswar	Consequences of phase transition dynamics in neutron stars and in inflation
3	14.06.2018	Soumyabrata Chatterjee IOP, Bhubaneswar	Field Theory On Cosmological Space time: Some Results from AdS/CFT
4	18.06.2018	Subhadip Jana IOP, Bhubaneswar	Tailoring Correlated Electron Oxide Thin Films and Interfaces
5	21.06.2018	Bharat Kumar IOP, Bhubaneswar	Implications of Nuclear interaction for nuclear structure astrophysics within the RMF model
6	25.06.2018	Mahesh Saini IOP, Bhubaneswar	Ion-beam induced patterning of materials and their application in solar cell research
7	26.06.2018	Alapan Dutta IOP,Bhubaneswar	Hole-blocking solar cell
8	26.06.2018	Amina Khatun IOP, Bhubaneswar.	Constraining New Physics with Atmospheric Neutrinos at IINO- ICAL
9	13.07.2018	Amit Kumar IOP, Bhubaneswar	Microstructure formation on Chromosomes.
10	18.07.2018	Shreyansh Shankar Dave IOP, Bhubaneswar.	Superfluid Transition, Topological Vortices, and Magneto- hydrodynamic Simulations for Relativistic Heavy-ion Collisions.
11	25.07.2018	Sudipta Mahana IOP, Bhubaneswar.	Magnetic & Ferro-Electric Properties of someAdvance functional oxide & Related Phenomena.
12	08.08.2018	Puspendu Guha IOP, Bhubaneswar.	Silver Nanostructures on Oxide Surfaces:Growth, Characterizations and Applications
13	13.08.2018	Sabya Sachi Chatterjee	Exploring Light Sterile Neutrinos and Long-Range

		IOP, Bhubaneswar.	Forces in Long-Baseline Experiments
14	27.08.2018	Sumit Nandi IOP, Bhubaneswar	Quantum Information processing protocols and entanglement.
15	12.11.2018	Chandan Datta IOP, Bhubaneswar	"Quantification and characterization of entanglement and coherence"
16	22.11.2018	Bharat Kumar IOP, Bhubaneswar	Implications of nuclear interaction for nuclear structure and astrophysics within the relativistic mean-field model (Thesis Defense)
17	28.11.2018	Nirakar Sahoo IOP, Bhubaneswar	Neutrino Mass, Anomalous Magnetic Moment of Muon and Dark Matter in a simple framework
18	30.11.2018	Minati Biswal IOP, Bhubaneswar	Temperature and temporal lattice site dependence in lattice QCD and study of Pulsars asdetectors of gravitational wave
19	30.11.2018	Tapoja Jha IOP, Bhubaneswar	FCNC Rare Decays and Flavour Maximal Scenario of non-minimal Universal Extra Dimensional Model
20	20.12.2018	Soumya C. IOP, Bhubaneswar	Exploring new physics at long-baseline neutrino experiment
21	24.12.2018	Ranveer Singh IOP, Bhubaneswar	Growth and characterization of CdTe-based multijunction hole-blocking solar cell.
22	04.01.2019	S.S Dave, IOP, Bhubaneswar	Superfluid Transition, Topological Vortices and Magneto-hydrodynamic Simulations for Relativistic Heavy-ion Collisions
23	29.01.2019	Paramita Maiti, IOP, Bhubaneswar	MBE grown molybdenum oxide nanostructures: Growth, Characterizations, and applications.
24	15.03.2019	Pronoy Nandi, IOP, Bhubaneswar	Structural and Spectroscopic Investigations of Organic- Inorganic Hybrid Lead Halide Perovskites.

4.2.3. Seminar of High Energy Physics Group

1	10.04.2018	Prof. Subhendra Mohanty PRL, Ahmedabad	Inflation and Early Universe
2	12.04.2018	Prof. Subhendra Mohanty PRL, Ahmedabad	Introduction to inflation
3	19.04.2018	Mr. Kasinath Das HRI, Allahabad	Vector-like quarks in some gauge extensions of Standard Model.
4	01.05.2018	Prof.A.K.Jaiswal NISER, Bhubaneswar	Relativistic dissipative hydrodynamics from kinetic theory
5	21.05.2018	Dr. Aruna K.Nayak IOP, Bhubaneswar	Observation of tt(bar)H production at CMS
6	24.05.2018	Dr.Narendra Sahu IIT, Hyderabad.	Darko-lepto-genesis for dark matter and baryon asymmetry of the Universe
7	08.06.2018	Dr. Monojit Ghosh T.M. Univ., Japan	Current status of light sterile neutrino and its effect in neutrino oscillation
8	11.06.2018	Sarif Khan	Singlet-Triplet Fermionic Dark Matter and LHC

		HRI, Allahabad	Phenomenology
9	24.07.2018	Dr. Frank F. Deppisch, Univ. College London, U.K.	Neutrinoless Double Beta Decay and BSM Physics
10	30.07.2018	Prof. Santosh Kumar Rai HRI, Allahabad.	Search for light Higgsinos at LHC with a Right-neutrino LSP
11	09.11.2018	Ananya Mukherjee Tezpur University	Connecting neutrino physics and related cosmology within beyond standard model frameworks
12	19.11.2018	Sanjoy Mandal,IMSc	Search for sterile neutrinos at colliders
13	22.11.2018	Dr. Gouranga Kole University of California, San Diego	Measurement of Higgs boson properties in the H to diphoton decay channel at LHC.
14	18.12.2018	Bibhuti Parida, Tomsk State University, Russia	Search for dark matter production in association with a hadronically decaying vector boson at the ATLAS experiment
15	19.12.2018	Dr. Sujoy Poddar Diamond Harbour Womens University, West Bengal	Searches for Electro weakinos at the Large Hadron Collider
16	21.12.2018	Shankha Banerjee Durham University	Constraining certain Higgs couplings at the HL-LHC And beyond.
17	16.01.2019	Prof. Genevieve Belanger, LAPTh,Annecy	Micromegas: a tool for dark matter studies.
18	23.01.2019	Prof. Genevieve Belanger, LAPTh, Annecy	TBA
19	24.01.2019	Prof. Eung Jin Chun's KIAS, Korea	TBA

4.2.5. Seminar of High Energy Physics Group (TPSC)

1	02.05.2018	Prof.S.N.Mishra TIFR, Mumbai.	Isomerism in Condensed matter Physics
2	16.11.2018	Dr. Aritra Biswas (IACS, Kolkata)	b → clv anomalies in light of vector and scalar interactions
3	26.12.2018	Dr. Raghavendra Rao Juluri, Dr APJ Abdul Kalam IIIT Ongole, AP	Impact of SiGe layer on SiC growth on Si
4	08.01.2019	Dr. Mehedi Masud, IFIC, University of Valencia, Spain	Exploring Lorentz Invariance Violating (LIV) Parameters at DUNE and its impact on octant studies.
5	13.02.2019	Dr. Ananya Mukherjee Tezpur University	Leptogenesis in a normal hierarchy neutrino mass model

4.2.6. Astrophysics Seminar

1	29.01.2019	Prof. Sarira SahuInstitute of Nuclear Science National Autonomous University of Mexico	Are blazars sources of High energy neutrinos?

4.2.7. Seminar of Condensed Matter Physics Group

1	06.04.2018	Dr Sk. Firoz Islam	Application of Floquet

			theory in Dirac materials
2	10.04.2018	Dr. Sandeep Choubey Harvard University, USA	Characterizing the gene expression dynamics of cell differentiation
3	20.04.2018	Mr.Sudarshan Saha	Berry Phase and Haldane model
4	24.05.2018	Dr. S.S Acharya IOP, Bhubaneswar	Electronic Structure Studies Using Angel Resolved Photoelectron Spectroscopy
5	28.05.2018	Dr. Sunita Srivastava IIT, Bombay.	Structure - property correlation in bio-inspired materials
6	18.06.2018	Dr Ranjan Modak Penn. state Univ., U.S.A	Emergent eigenstate solution and work extraction
7	25.06.2018	Dr. Surender Pratap BITS Pilani	Quantum transport in the confined region of potential well and quantum disordered wire case
8	12.07.2018	Dr. Ajeet Sharma Penn. State Univ., USA	Non-equilibrium coupling of protein structure and function to translation-elongation kinetics
	09.07.2018	Avijeet Ray IIT, Roorkee.	First Principle Study of Transport and magnetic Properties of certain correlated materials
9	26.07.2018	Dr. Jaspal Singh, SBAS, GGSI Univ., New Delhi.	Development of noble metal-TiO2 plasmonic nanohybrids andnanocomposites for photocatalytic applications
10	21.08.2018	Dr. Sanjukta Paul SINP, Kolkata.	Giant magnetoelectric effect in manganite heterostructures and the ferromagnetic-insulator Phase in manganites.
11	21.08.2018	Satyaki Kar IACS, Kolkata.	Photo-induced Entanglement in a Magnonic Floquet Topological Insulator
12	27.08.2018	Sumit Majumdar SINP / Jadavpur University Kolkata	Synthesis, characterization and exploring potential application of some iron oxide and gold based functional nano and micro Structures.
13	05.10.2018	Dr. Firoz Islam IOP, Bhubaneswar	Electronic Band Structure and Transport Properties of Irradiated Dirac/semi-Dirac Material
14	12.10.2018	Dr. Debabrata Sinha IACS, Kolkata	Transport in multi-Weyl Semimetal Junctions
15	23.10.2018	Dr. Narender Kumar Inter-University Accelerator Centre	Commissioning of 2.45 GHz Microwave Ion Source based High Flux system for ion implantation in materials
16	30.10.2018	Dr. Maiikarjuna Rao Motapothula,Tandem Laboratories,Uppsala University.	Sub-Å focused ion beams by the aid of ion channeling crystals
17	29.11.2018	Dr. Krishnamohan Tripathi HRI, Allahabad, India	Transport signatures of Majorana zero modes in an Aharonov-Bohm geometry
18	17.01.2019	Prof. S. D. Mahanti, Michigan State University, USA	Trivial (ordinary) Insulators: Spin-driven Magneto-electric (ME) phenomena
19	24.01.2019	Prof. S. D. Mahanti, Michigan State University,	Topological Insulators: Orbital-driven ME phenomena and AxionElectrodynamics Axion

		USA	physics in non-topological insulators
20	27.02.2019	Dr. Safiul Mollick IIT Roorkee, NPDF	Tailoring magnetic properties of thin film on patterned substrate
21	14.03.2019	Dr. P. Sekhar Burada IIT-Kharagpur	A hydrodynamic-stochastic model of chemotactic ciliatedmicroorganisms
22	18.03.2019	Dr. Dipanjan Chakraborty IISER Mohali	Self-thermophoretic motion of a Janus particle - a molecular dynamics study
23	28.03.2019	Saroj Kumar Mishra, Research-Scholar, UGC-DAE Consortium for Scientific Research, Indore	Magneto-transport and calorimetric studies of magnetic transitions in co(s1-xsex)2

4.2.8. Experimental Nuclear Physics Seminar

1	14.05.2018	Dr.Jatis K. Dash SRM, Amaravati	Van der Waals epitaxy on 2D Layers

4.2.9. Quantum Information Seminar

1	23.07.2018	Shrobona Bagchi IIT, Kanpur.	Tighter and reverse uncertainty relations for Hermitiar and Unitary operators
2	05.10.2018	Sibasish Ghosh, IMSc	Universal detection of entanglement in two-qubit states using only two copies

4.2.10. String Theory Seminar

1	18.03.2019	Prof. Diptarka Das, IIT Kanpur	Modular Bootstrap With Applications to Thermalization
2	19.03.2019	Prof. Diptarka Das, IIT Kanpur	Modular Bootstrap With Applications to Thermalization

4.3 LECTURES DELIVERED BY THE INSTITUTE MEMBERS

4.3.1 POPULAR TALKS

TITLE OF TALK	EVENT / PLACE & DATE
" The universe" and discussion on "career choices"	**Prof. A. M. Srivastava:** atBigyan Jyoti program for girl students, IIT Bhubaneswar, 18 June, 2018.
"Detection of gravitationalwaves"	**Prof. A. M. Srivastava:** at NATIONAL SCIENCE TEMPER DAY, for school students at IOP, 20th Aug. 2018.
"Brahmand ki sanrachna (structure of the universe)"	**Prof. A. M. Srivastava:** given at the "Interactive sessions of science teachers and students" for High school teachers and students (Oriya medium) from across odisha, organized by Odisha Bigyan Academy. Program held at the Institute of Management of Agricultural Extension (IMAGE), Bhubaneswar,8-9 Sept. 2018.
"Importance of Hindi as medium of communication"	**Prof. A. M. Srivastava:** atChief guest talk at Doordarshan Kendra, for Hindi Pakhawada samapan samaroh, 1st Oct. 2018
"Universe and elementary particles"	**Prof. A. M. Srivastava:** at college students vis-iting IOP, Bhubaneswar, Dec. 2018.
"Gravitational waves"	**Prof. A. M. Srivastava:** atto school students in Young Astronomers Talent search program of Tata Steels, at IOP, Bhubaneswar, 13 Dec. 2018.
Microscopy: Technology Advances for Mankind	**Prof. P.V.Satyam**: at For undergraduate students of P.B. Siddhartha College, Vijayawada, December 18, 2018
Nuclear Physics and its applications	**Prof. S.K. Patra:** at Department of Physics, Sambalpur University, In Alumni Meeting.
Raman Spectroscopy for the characterization of Low Dimensional Materials	**Dr. Satyaprakash Sahoo :**at *KIIT University, Bhubaneswar*
Understanding the fundamental Constituents of matter	**Dr.A.K.Nayak:** at Science Day Talk to school students, Institute of Physics, Bhubaneswar, 28th Feb 2019.

4.3.2. Seminars/Talks Delivered

TITLE OF TALK	EVENT / PLACE & DATE
Prof. S. M. Bhattacharjee	
Surprises with DNA	Colloquium at Ashoka University, Sept 2018
DNA near its melting point	Puri Polymer Conference, Dec 2018
Dynamical Quantum Phase transitions	*NISER_IOP Journal Club, Jan 2019*
Dynamical quantum Phase transitions	Colloquium, SQUniversity, Muscat Oman, March 2018
Prof. A. M. Srivastava	
High density qcd phase transitions inside neutron stars: glitches and gravitational waves"	The School of Physical Sciences, Jawaharlal Nehru University, New Delhi, 12th April, 2018,
High density qcd phase transitions inside neutron stars: glitches and gravitational waves"	The Physics Dept. Delhi University, Delhi, 13th April, 2018.
"Magneto hydrodynamics simulations, flow, flow fluctuations, and vortices",	Given at the "ii internationalworkshop on simulations of hic for nica energies", held at the joint institute for nuclearresearch (jinr), Dubna, Russia, 16-19 April 2018.
"Thermal History of the Universe"	At ocsc hbcse meeting for the selection of Indian team for the international Olympiad inastronomy and astrophysics, may 3-5, 2018.
Talk on "cosmology"	at the lecture workshop on "Higher EnergyPhysics "at the maharajahs college, vizianagaram, august 9-10, 2018
Detection of gravitational waves, a new window to the universe".	at the lecture workshop on "Higher EnergyPhysics "at the maharajahs college, vizianagaram, august 9-10, 2018
"Towards laboratory detection of superfluid phases of QCD"	given at Physics Dept. Brookhaven National Lab, USA, 9th Nov.2018
"Cultivation of Scientific Temper: Focus on Indian Science Community"	given at the conference on "Integrating science with society" 15 December 2018, Jadavpur University, Kolkata.
"Investigating cosmic string theories in liquid crystal experiments"	Colloquium given at Physics Dept. Univ. of Nebraska, Lincoln, USA,31st Jan., 2019.

Multi-step electroweak phase transitions and gravitational wave generation.	Physics Dept. Univ. of Nebraska, Lincoln, USA during 15th Jan.-8th May 2019.

Prof. S. Varma

DNA as a Sensor of Nanoparticles: Unzipping and changing Persistence length of DNA	International Conference on Microscopy and XXXIX Annual Meetingof EMSI 2018, at Mayfair Lagoon, Bhubaneswar (July 2018)
Nanotechnology Viewing Atoms and Nanostructures	Uday NathCollege, Adaspur. (Sept. 2018)
Ion Beam Modified Surfaces, Roughness, Scaling properties, Fractal properties,	International School on Ion Beams in Material Science', organized by IUAC, New Delhi (Oct 2018).
X-ray Photoelectron Spectroscopy (XPS)	International School on Ion Beams in Material Science', organized by IUAC, New Delhi (Oct 2018).
DNA as a Sensor of Nanoparticles: Unzipping and Changing Persistence Length of DNA	*University of Nebraska, Lincoln, USA (March 2019).*
Atomic Force Microscopy for the Study of Surfaces, Nanostructures and DNA	At pre-conference workshop of International Conference on Microscopy and XXXIX Annual Meeting of EMSI 2018, at IOP Bhubaneswar (July 2018)

Prof. P. Agrawal

'Tripartite Nonlocality', in \Quantum Frontiers and Theoretical Rami cations"	Fundamentals (QFF2018): Experimental Studies and Raman Research Institute,Bengaluru, India, April 30 - May 4, 2018.
'Quantum Entanglement', Three hours lectures in the school part of 'National Work-shop on Quantum Information and Information Security (NWQIIS)'	IIIT Hyderabadfrom October 5 - 11, 2018.

Prof. B. R. Sekhar

Band Structure of some Quantum Materials	Invited talk at RDCMP, UN College, Adaspur
Tuning of Surface State Bands in Some Topological Insulators	Invited talkat Materials Science Conclave, IISc, Bangalore
Surface State Bands in a weak Topological Insulator	Invited talkat AESET-2019, Dresden, Germany.
Surface State Bands in a weak Topological Insulator	Invited talkat FQM-NISER, 2019.

Prof. P. V. Satyam

Coherently Embedded Ag Nanostructures: Growth, Characterization and Applications	Invited talk on 21.06.2018 Jeju Island, S. Korea
Self-assembled Nanoscale Modification of Metal and Metal-Oxide interfaces: Electron Microscopy and Insitu XRD study	Invited talk on 10.09.2018International Convention Centre, Sydney, Australia

Prof. T. Som

"Surface patterning by ion beams"	Colloquia on 04.05.2018 at *CEMES-CNRS*, Toulouse, France.
Self-organized nanostructure formation by ion beams"	Colloquia on 28.05.2018 at Ion Beam Centre, Helmholz-Zentrum Dresden-Rossendorf, Germany.
"Resistive switching"	On 06.07.2018 at 64th AUC Workshop, IUAC, New Delhi.
Importance of atomic force microscopy in multifunctional materials	On 17.07.2018 in Workshop on Surface Probe Microscopy, Bhubaneswar.
"Formation of ion-beam induced self-organized surface nanostructures"	On 19.07.2018 at International Conference EMSI-2018, Bhubaneswar.
"Nanoscale Surface patterning by Ion Beams (IBMEC-2018)	On 10.10.2018 at International Conference on Ion Beams in Materials Engineering and Characterization, IUAC, New Delhi.
Nanoscale self-organized surface patterning by ion beams and their applications"	On 14.12.2018 at International Conference on Materials Science and Technology at Calcutta University, Kolkata.
"Improved photovoltaic performance of CdTe solar cells: Role of a hole-blocking layer"	On 12.02.2019 at International Conference on Efficient Solar Power Generation and Energy Harvesting (ESPGEH-2019) at Amity University, Noida.
"Improved photovoltaic performance of CdTe multi-junction cells: Role of a hole-blocking layer"	On 22.02.2019 at National Conference on Frontiers in Physics at IACS, Jadavpur, Kolkata.
"Improved photovoltaic performance of CdTe multi-junction cells: Role of a hole-blocking layer"	On 04.03.2019 at 12th India-Singapore Physics Symposium at Puri.
"Atomic force microscopy: What can we do?"	On 30.03.2019 at School of Applied Sciences, KIIT University, Bhubaneswar.

Prof. S. K. Patra

Effective Surface Properties of Sn isotopes, Invited talk given at *International conference on Nuclear, Particle and Accelerator Physics (INCPAP-2018),*	October 23-*26, 2018, Central University of Jharkhand, Ranchi.*

Effective surface properties of light, heavy, and super- heavy nuclei, Collective Flow and Sub Threshold Particle Production in Heavy Ion reactions",	*Invited talkgiven at Indo-French Seminar on "Multifragmentation* Panjab University Chandigarh Feb 4-6, 2019.
Tidal deformability and Gravitational Waves	*Invited talk given at International Seminar on "Emerging Trends in Physicsand Applications" 2-4, February 2019.*
Nuclear Physics and its Applications	Invited talk given at the National Seminar onRecent Trends in Physical Sciences (RTPS-2019), Rajendra College, Balangir, 15-16,February 2019.

Dr. S. K. Agarwalla

Neutrino Oscillation: Present Status and Future Prospects	Invited talk given at the National Seminar on Recent Advances in Physics(NSRAP-2019), P.G. Department of Physics, Berhampur University, Berhampur,Odisha, India, 23rd March, 2019
Discussion on Light Sterile Neutrino	IITB - ICTP Workshop on Neutrino Physics, IIT Bombay, Mumbai, India, 14thDecember, 2018
Atmospheric *V* Oscillation: Celebrating 20 years of SK Discovery & Beyond	Seminar given at ICTP, Trieste, Italy, 17th September,2018
Addressing Neutrino Mixing Models with T2HK and DUNE	Invited talk given at the Neutrino Oscillation Workshop (NOW) 2018, Ostuni,Italy, 14th September, 2018
Neutrino Physics: An Introduction	Two pedagogical lectures given during the Lecture Workshop on High EnergyPhysics at Department of Physics, Maharajah's College(Autonomous), Vizianagaram,Andhra Pradesh, India, 9th to 10th August, 2018
Oscillation with Three Active and One Light Sterile Neutrinos	Seminar given at ICTP, Trieste, Italy, 7th June, 2018
Sensitivity of Long-baseline Experiments with a Sterile Neutrino	Seminar given at INFN Padova, Italy, 25th May, 2018
Light eV-scale Sterile Neutrino in Long-baseline Experiments	Seminar given at INFN Rome, Rome, Italy, 14th May, 2018

Dr. Dinesh topwal

Invited Talk	Delivered a invited lecture at 63rd DAE Solid state Physics Symposium, Hisar, Haryana

Quantum matter	Delivered a invited lecture at a Forum NISER, Bhubaneswar
Dr. A. Saha	
"Few transport phenomena through Superconducting hybrid junctions of Diracmaterials"	Harish Chandra Research Institute (HRI), Allahabad, 02nd May (2018).
"Majorana Zero Modes in mixed singlet and triplet superconducting nanowire"	Quantum Matter - 2018, IISER- Mohali, 25th July (2018).
"Majorana Zero Modes in mixed singlet and triplet superconducting nanowire"	Young Investigator Meet in Quantum Condensed Matter Theory,SNBNCBS (Kolkata), 22nd November (2018).
"Majorana Zero Modes in mixed singlet and triplet superconducting nanowire"	12th India-Singapore Physics Symposium (ISPS 2019), Puri, 04th March, (2019).
Dr. Saptarshi Mandal	
"Classical mean-field, spin-wave, and perturbative continuous unitary transformation analyses of the squaric acid system H2SQ "	Young Investigator Meet On Quantum Condensed Matter Theory "from 20th to 22nd November2018 at S N Bose National Centre for Basic Sciences Kolkata.
Dr. Satyaprakash Sahoo	
Intense Ultraviolet Emission from ZnO Nanorods Grown on Graphene	*NIT Surat*
Dr. A. K. Nayak	
Searches for ttH production at CMS,	Proceedings of XXVI International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2018), 16-20 April 2018.
Higgs boson production in association with a top quark pair at CMS	IOP HEP-Seminar, Bhubaneswar, 21st May 2018.
BSM Higgs Searches at LHC	Invited mini-review Talk, DAE-BRNS Symposium on HEP, IIT Madras, 10-14th December 2018.
Measurement of Higgs boson properties at LHC	Ravenshaw University, Cuttack, 10th November 2018.
Use of Boosted Decision Trees in High Energy Physics	"RECAPP activity, HRI, Allahabad",6th March 2019
Basics Concept of Artificial neural networks	"RECAPP activity, HRI, Allahabad,"7th March 2019
Use of multivariate methods in CMS physics analyses	RECAPP activity, HRI, Allahabad, 8th March 2019
Tutorials on the use of BDT and XGBoost	"RECAPP activity, HRI,"Allahabad, 6th to 8th March 2019

Dr.Debasish chaudhuri

"Entropic forces behind Organization of bacterial chromosome"	Invited lecture at the physicsdepartment, IISER-Mohali, on 29th May, 2018
"Confinement and crowding sets morphology and position of bacterial chromosome	Invitedlecture in the international conference on "Entropy, information and order in soft matter", at ICTS-TIFR Bangalore, on 29th August, 2018
Cross-linker mediated organization and collapse in a model chromosome	Invited lecture inthe International Conference on Complex and Functional Materials (ICCFM) celebrating 125th birthanniversary of Prof. S. N. Bose, organized by the S N Bose National Centre for Basic Sciences, on15th December, 2018
Entropic organization of bacterial chromosome",	Guest Lecture on Research Scholars' day,Centre for Theoretical Studies (CTS), IIT-Kharagpur, 1st February, 2019.
Entropic organization of bacterial chromosome",	At 10th year of Department of PhysicalSciences, DPS@10, at IISER-Kolkata, on 23rd February, 2019.
"Chromatin organization by cross-linkers: a passive route",	In the conference ISPCM-19 atICTS-TIFR, on 16th February, 2019.

Dr. S. Banerjee

Quantum space-time seminar	*TIFR Mumbai, 24/09/2018*
String Theory Seminar	*IISER Pune, 14/11/2018*
5-th Indo-Israeli Meeting on string theory	Nazareth, Israel, 17/02/2019 - 21/02/2019
Gravity at different length scales	*IACS Kolkata, 25/02/2019 - 27/02/2019*
Soft-holography	*IISER Pune, 02/03/2019 - 04/03/2019*

Dr. D. Samal

Designer thin-film heterostructure of quantum materials and novel phenomena	Seminar for faculties for training and academic development on frontiers in experimental and theoretical physics, 24-27, April 2018, Department of Physics, College of Engineering and Technology, Bhubaneswar (Invited talk)
Tailoring the electronic properties of thin-film heterostructures of quantum materials	24th January October,Physics Department, NIT Rourkela, (Invited talk)
Tailoring the electronic and magnetic properties of $SrCoO_{3-ä}$/$SrCoO_{2.5}$ interface and rocksalt type CuO layer	International Conference on Complex & Functional Materials (ICCFM-2018), 13-16, December 2018, S. N. Bose National Centre for Basic Sciences. **(Invited talk)**

properties of $SrCoO_{3-ä}/SrCoO_{2.5}$ interface and rocksalt type CuO layer	First Indian Materials conclave and30th Annual general meeting of MRSI, 12-15, Feb 2019, IISc Bangalore. (Invited talk) (Also co-chaired the theme symposia on MAGNETIC, SPINTRONICS AND SUPERCONDUCTORS)
Tailoring the electronic and magnetic properties of $SrCoO_{3-ä}/SrCoO_{2.5}$ interface and rocksalt type CuO layer	12th India- Singapore -Physics Symposium, 2-4, March 2019, Toshali Sands Puri, India.
Designer thin film heterostruture of quantum materials and novel phenomena	7th Max Planck Partner Group Meeting 15-16 March, 2019, Mumbai
Dr. M.Mitra	
Seesaw at a Lepton Collider, andTechnology.	January 11th,2019, Hong Kong University of Science
Heavy Neutrino Searches at Collider	February,2019. Neutrino activity week, HRI, Allahabad,
Dr. K.Ghosh	
Series of Lectures on THEP	At SERC Preparatory School (University of Hyderabad).

4.4. CONFERENCE / WORKSHOP ATTENDED BY IOP MEMBERS

Name	Conference/Workshop details
Prof. S. M. Bhattacharjee	(1) Director, Science Academies' Refresher Course on statistical Physics, Bishop Moore College, Kerala (2) Co-Organizer, Puri Polymer Conference, Dec 2018
Prof. A. M. Srivastava	1) Attended the "II International Workshop on Simulations of HIC for NICA energies", held at the Joint Institute for Nuclear Research (JINR),Dubna, Russia, 16-19 April 2018. 2) Attended the Lecture workshop on "Higher Energy Physics" at the Maharajahs College, Vizianagaram, August 9-10, 2018 3) Attended the conference on "Integrating science with society" 15-16 December 2018, Jadavpur University, Kolkata.
Prof. S. Varma	1.International Conference on Microscopy and XXXIX Annual Meeting of EMSI 2018,at IOP, Bhubaneswar (July 2018) 2. Visited IUAC, New Delhi: for giving two Invited Lectures at International School on Ion Beams in Material Science', organized by IUAC, New Delhi (Oct 2018).
Prof. P. Agrawal	1. 'Tripartite Nonlocality', in \Quantum Frontiers and Fundamentals (QFF2018): Experimental Studies and Theoretical Ramications" at the Raman Research Institute,Bengaluru, India, April 30 - May 4, 2018. 2 'Quantum Entanglement', Three hours lectures in the school part of 'National Work-shop on Quantum Information and Information Security (NWQIIS)' at IIIT Hyderabadfrom October 5-11, 2018.
Prof. B. R. Sekhar	1. RDCMP, UN College, Adaspur 2. Materials Science Conclave, IISc, Bangalore 3. AESET-2019, Dresden, Germany. 4. FQM-NISER, 2019.
Prof. P. V. Satyam	**1. Annual Meeting of Korean Society of Microscopy:**Presented a talk during KSM meeting in Juju Island, South Korea on Endotaxy: During 18 – 22 June 2018, Juju Island, South Korea

	2. **International Microscopy Congress,** 09 – 14 September 2018 Presented a talk on 10th September 2018: Sydney, Australia (once infour years, IFSM/ ICSU organized) 3. **International Conference on Green Energy Technologies for Smart Cities 2018,** SRM AP Amaravati, December 19–21, 2018Amaravati, Vijayawada, AP; Talk Title: Electron Microscopy studies of energy materials; 20.12.2018 4. ANDHRA PRADESH AKADEMI OF SCIENCES, AMARAVATI **An International Seminar on "Nanotechnology for the future energy challenges**" at P.B. Siddhartha College, Vijayawada, December 18, 2018 Talk title: Microscopy: Technology Advances for Mankind
Prof. S. K. Patra	1. International conference on Nuclear, Particle and Accelerator Physics (INCPAP-2018), October 23-26, 2018, Central University of Jharkhand, Ranchi. 2. Indo-French Seminar on "Multifragmentation, Collective Flow and Sub Threshold Particle Production in Heavy Ion reactions", Panjab University Chandigarh Feb 4-6, 2019. 3. International Seminar on "Emerging Trends in Physicsand Applications" 2-4, February 2019.
Prof. T. Som	1. AUC Workshop, IUAC, New Delhi. 2. Workshop on Surface Probe Microscopy, Bhubaneswar. 3. International Conference EMSI-2018, Bhubaneswar. 4. International Conference on Ion Beams in Materials Engineering and Characterization, IUAC, New Delhi. 5. International Conference on Materials Science and Technology at Calcutta University, Kolkata. 6. International Conference on Efficient Solar Power Generation and Energy Harvesting (ESPGEH-2019) at Amity University, Noida. 7. National Conference on Frontiers in Physics at IACS, Jadavpur, Kolkata. 8.12th India-Singapore Physics Symposium at Puri. 9. ICONN-2019 at SRM University, Chennai.
Prof. P. K. Sahu	1. Attended the ALICE-India Collaboration Meeting - February 13-16, 2019, Bose Institute, Kolkata

	2. Visited to CERN for shifts and ALICE-TPC experiment from 30th September to 16th October, 2018. 3. Attended the ALICE-India Collaboration Meeting - September 17-20, 2018, NISER, Bhubaneswar, Odisha. 4. Visited to CERN for shifts and ALICE-TPC experiment from April 1st to 3rd May, 2018
Dr. S. K. Agarwalla	1. National Seminar on Recent Advances in Physics (NSRAP- 2019), P.G. Department of Physics, Berhampur University, Berhampur, Odisha, India, 23rd to 24th March, 2019 2.SERB School on Experimental High Energy Physics, TIFR, Mumbai, India, 24th to 26th January, 2019 3. Vision Scheme - 7 (VS7) Sub-committee Meeting to review the Mega Science Projects of DAE, IPR, Gandhinagar, India, 3rd January, 2019 4. IITB - ICTP Workshop on Neutrino Physics, IIT Bombay, Mumbai, India, 14th to 18th December, 2018 5. Academic visit to ICTP, Trieste, Italy, 5th to 19th September, 2018 6. Neutrino Oscillation Workshop (NOW) 2018, Ostuni, Italy, 9th to 16th September, 2018 7. Lecture Workshop on High Energy Physics at Department of Physics, Maharajah's College (Autonomous), Vizianagaram, Andhra Pradesh, India, 9th to 10th August, 2018 8. Advanced workshop on Physics of Atmospheric Neutrinos - PANE 2018, ICTP, Trieste, Italy, 28th May to 1st June, 2018 9. Academic visit to ICTP, Trieste, Italy, 8th May to 18th June, 2018 including a visit to INFN, Rome (14th - 15th May) and INFN, Padova (25th - 26th May), Italy10. Dark Matter experiment at Jaduguda Underground Science Laboratory (JUSL) First National Level Collaboration Meeting, SINP, Kolkata, India, 12th April 2018
Dr. GoutamTripathy	12th India-Singapore Physics Symposium, Puri, 2-4 March 2019
Dr. Dinesh Topwal	1.63rd DAE Solid state Physics Symposium, Hisar, Haryana2. Workshop on R&D opportunities in defence sector held at CSIR-IMMT, Bhubaneswar.
Dr. ArijitSaha	1.Quantum Matter-2018, IISER- Mohali, 25 - 27 July (2018).2.Young Investigator Meet in Quantum Condensed Matter Theory, SNBNCBS (Kolkata),

	20-22 November (2018).3.12th India-Singapore Physics Symposium (ISPS 2019), 02-04 March (2019).
Dr.Saptarshi Mandal	1. Young Investigator Meet On Quantum Condensed Matter Theory from 20th to 22nd November 2018 at S N Bose National Centre for Basic Sciences Kolkata. 2. Annual meeting of IOP-NISER meeting held at NISER 3. Indo-Singapore meeting at Puri, Odisha
Dr.Satya Prakash Sahoo	1.International Conference on Recent Trends In Nanomaterials For Clean Energy (ICRTNCE-2019), NIT Surat
Dr. Aruna K Nayak	1.XXVI International Workshop on Deep-Inelastic Scattering and Related Subjects (DIS2018), 16-20 April 2018 2.DAE-BRNS Symposium on HEP, IIT Madras, 10-14th December 2018 3.International Meeting on High Energy Physics, 17th – 22nd January, 2019, IOP, Bhubaneswar (Co-convener of the meeting) 4. RECAPP activity period meeting, HRI, Allahabad, 5th – 9th March 2019.
Dr. DebasishChaudhuri	1. Soft Matter Young Investigators Meet-2018, Shimla, 23-25 May, 2018 2. International conference on "Entropy, information and order in soft matter", at ICTS –TIFR Bangalore, 29-31 August, 2018 3. "International Conference on Complex and Functional Materials", organized by the S N Bose National Centre for Basic Sciences, 13-16 December, 2018. 4. DPS@10, at IISER-Kolkata, 23-25 February.5. Indian Statistical Physics Community Meeting, ICTS-TIFR Bangalore, 14-16 February, 2019.
Dr. S. Banerjee	1) 5-th Indo-Israeli Meeting on string theory, Nazareth, Israel, 17/02/2019 - 21/02/2019. 2) Gravity at different length scales : IACS Kolkata, 25/02/2019 - 27/02/20193) Soft-holography: IISER Pune, 02/03/2019 - 04/03/20194) Recent topics in string theory and cosmology : NISER, Bhubaneswar, 28/03/2019 - 31/03/2019
Dr. D. Samal	1. Training and academic development on frontiers in experimental and theoretical physics, 24-27, April 2018, Department of Physics, College of Engineering and Technology, India 2. 24th January October, **Physics** Department, NIT Rourekela**.**

	3. International Conference on Complex & Functional Materials (ICCFM-2018), 13-16, December 2018, S. N. Bose National Centre for Basic Sciences,India, 4. First Indian Materials conclave and30th Annual general meeting of MRSI, 12-15, Feb 2019, IISc Bangalore. 5. 12th India- Singapore -Physics Symposium, 2-4, March 2019, Toshali Sands Puri, India. 6. 7th Max Planck Partner Group Meeting 15-16 March, 2019, Mumbai, India.
Dr. ManimalaMitra	1. IAS Program on High Energy Physics 2019, HKUST Jockey Club Institute for Advanced Study, Hong Kong University of Science and Technology, January 7th-18th, 2019 2. Neutrino activity week, February 21st-26th, 2019, Harish-Chandra Research Institute, Allahabad, India3. International Meeting on High Energy Physics, Institute of Physics, Bhubaneswar, India,January 17th to 22nd, 2019
Dr. Kirtiman Ghosh	1. "Is SUSY still the best bunker to hide in, in light of experimental data?" at Centre for High Energy Physics, Indian Institute of Science during May 9-13, 2018. 2. "Collaboration Meeting on dark matter experiment at Jaduguda" at SINP on April 12, 2018.

4.5. AWARDS / HONOURS AND RECOGNITIONS

Prof. A. M. Jayannavar

- Prof. A. M. Jayannavar's J.C. Bose National Fellowship has been extended from 01.01.2019 to 31.12.2023.

Prof. P. V Satyam

- Guest Editor: Microscopy and Microanalysis (regular journal belonging to Cambridge University Press, UK)
- Selection Committee member of Faculty/Scientist recruitment/departmental promotion belonging to CSIR Institutes and University Grants Commission

Dr. ArijitSaha

- Elected as the member of "National Academy of Sciences (NASI)", India.

CONFERENCES AND OTHER EVENTS

5.1. Foundation Day

Institute of Physics, Bhubaneswar celebrated its 44th Foundation Day in its premises on 4th September, 2018.Professor D. D. Sarma, FASc, FNASc, FNA, FTWAS, FAPs, Indian Institute of Science, Bangalore 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 vote of thanks by Sri Rushi Kumar Rath, Register, Institute of Physics, Bhubaneswar. Before the program, Professor D. D. Sarma also delivered Foundation Day Colloquium on "A new generation of photovoltaic materials" at 3:30pm, meant for students and researcher from all branches of Physics. The talk was focused on his group research activities with "methyl ammonium lead halides" and related compounds which have extraordinary photovoltaic properties. He also explained how these materials can be useful to solve the Energy problem of the country.

Prof. Panda, Director of the Institute in his introductory speech emphasized on the mandates of IOP and highlighted many activities of last year like implementation of Health scheme for employees and retired persons, renovation of Guest House and many upcoming activities like, New Gate for IOP, 50+ single room hostel and Guest House etc. Prof. Sharma delivered a speech on "Nurturing Science & Miraculous World of Materials". He also highlighted how the current educational system is not suitable to develop a scientific attitude among the young children. At the end, to promote the dying art and culture of Odisha, professional troops of Mayurbhanj performed the Chhau Dance along with the popular Ghoda Nacha (Dummy Horse Dance) by a local troop. Dr. B. Mohanty, Convener extended his thanks to the IOP Community, Media Persons, and especially the Organizing Committee.

(Guests on Dias during the Foundation Day Celebration-2018)

5.2. Felicitation of Founder Director

Prof. Trilochan Pradhan @ 90 years

Institute of Physics, Bhubaneswar organized the "International Meeting on High Energy Physics (IMHEP) in the Institute during January 17th – 22nd, 2019. During this meeting on Morning Session of 21st January, 2019, Institute felicitated Prof. Trilochan Pradhan, Founder Director of the Institute of Physics (IOP), Bhubaneswar on his 90 years of age. Prof. Pradhan has not only made important contribution to various branches of sciences, but also contributed to the development of many institutions.

(Prof. Trilochan Pradhan is felicitating by Prof. Sudhakar Panda, Director)

5.3. International Meeting on High Energy Physics (IMHEP)

The International Meeting on High Energy Physics (IMHEP 2019) was held at Institute of

Physics (IOP), during 17th-22nd January, 2019. The organising committee members were Ajit M Srivastava, Pankaj Agrawal, Debottam Das, Manimala Mitra, Kirtiman Ghosh, Aruna Kumar Nayak, Sanjib Kumar Agarwalla. The theme of this year's meeting was collider physics.The main purpose of the meeting was to review the status of our current understanding of beyond the Standard Model (BSM) Physics and to make some definitive attempts in order to interpret the observations at LHC. Additionally, focus was made in predicting hidden corners of new physics at LHC or the other experimental facilities.

A total of 102 outside speakers and participants, including faculties from various reputed research institutions and universities, students and postdocs working in BSM physics attended the meeting.

There were a number of plenary talks presented by experts in the areas of Dark Matter, Standard Model Higgs, BSM Higgs physics, as well as neutrino mass models. The plenary talks were aimed to give an overview on the status of the field, and the plenary talks were followed by more specific and technical talks presented in the working group activities. The working group activities were held in the afternoon session on BSM Models and Phenomenology, Neutrino Models and Phenomenology, SM and BSM Higgs Phenomenology, QCD and Jet Physics, and Top Physics. The entire 6 days of academic activities have been distributed proportionately, with an excursion arranged for January 20th to visit Konark and Puri.

5.4. Puri Polymer Conference (PPC-2018)

A conference on the theoretical aspects of polymers was successfully held in Lotus Resort, Konark, during Dec 12-14 2018. There were around 35 scientists from India and abroad. Eminent theorists like M. Muthukumar (UMASS, USA), R. Granek (Israel), I. Ali (Oman), S. Nechaev (Moscow), A. Giacometti (Venice, Italy), and T. AlaNissila (Finland/UK) participated from abroad (J-U Sommer, Dresden, Germany, from IOP, Amit Kumar, Debjyoti Majumdar and S. M. Bhattacharjee participated, while Biplab Bhattacharjee and Amir Shee were day-participants. The good mix of senior andjunior scientists helped in very lively discussions.

The talks covered different aspects of polymers, like problems associated with DNA, RNA, proteins, polyelectrolytes, semi flexible polymers, randomness, anomalous statistics for highly deformed polymers, the controversial problem of polymer translocations, and several biological

applications. The state-of-the art presentations brought out the current scenario and open problems in polymer theory. The participants, especially the students and post-docs, expressed their happiness inthe format, varieties, quality, and seriousness of the presentations.

The conference was partially supported from the J C Bose Fellowship grant of S M Bhattacharjee and from the registration fees from the participants.

(Participants of PPC 2018)

5.5. National Frontiers of Engineering (NatFoE) Symposium

International Conference on Microscope and XXXIX Annual Meeting of Electron Microscope Society of India, 18 - 20 July, 2018 at Mayfair Convention Center, Bhubaneswar

This conference was organized by Electron Microscope Society of India (EMSI) in collaboration with Institute of Physics and other Institutes, such as, NISER, IIT-BBSR, CSIR-IMMT, DBT-ILS and CSIR-CGCRI. The conference was chaired by Prof. P. V. Satyam, who is Professor at IOP and also President of EMSI. About 550 participants from all over the world participated in the meeting that was held during 18 – 20 July 2018 at Mayfair Convention Center, Bhubaneswar. There were several

Plenary speakers (23) and Invited speakers (120) and 43 of them were from abroad, Several young researchers were given chance to present their work through contributed oral (about 150 speakers) and Posters (200) in the areas such as Natural sciences, Engineering and Medicine and Life Sciences. The topics included were Low-dimensional systems (Nanoscale, Nanostructured Materials, 2D layered systems, etc.), Thin films, Coatings, Surface and Interfaces, Industrial Applications of Microscope methods, Electron Microscope and Energy materials, Electron Microscope Insitu techniques, Radiation Damage and Defects, Electron Microscope of advanced engineering materials, High-resolution including aberration-corrected Microscope, Advances in Instrumentation and Techniques, Chemistry and Spectroscopic Techniques and their uses, Applications of Atom Probe Tomography, Microscope of Functional Materials, Diffraction, Crystallography and Aperiodic Structures, Imaging with Ions beams: Ion Microbeam, SIMS, He-ion Microscope, Bioremediation and Ore beneficiation; Bioremediation of toxic elements, Electron Microscope of Glass and Ceramic materials, Cryo-electron Microscope, Biomedical imaging, diagnostics, therapy and biotechnology, Novel molecular probes and tools for imaging, etc

Eight (8) pre-conference Workshops were also organized by Prof. P. V. Satyam along with other coordinators:

Out of these eight pre-conference workshops, three workshops (pre-conference) were held at IOP and Prof. S. Varma and Prof. T. Som took the care of other workshops at IOP. Out of three

workshops that were held at IOP during 16 – 17 July 2018, one was on FEGSEM- FIB/TEM, one on ESEM (Medicine) and One on SPM (scanning probe microscopy). More 100 participants (students and young faculty) participated and several speakers – from various institutes like BARC, IGCAR, IIT-KGP, AIIMS-Delhi, IOP presented the workshop talks. The other five (5) workshops were organized: two by NISER, One each by IIT-BBSR, ILS, IMMT.

5.6. 12th Singapore India Joint Physics Symposium

Report on "12th India-Singapore Physics Symposium (ISPS 2019)" jointly organized by Institute of Physics (IOP), Bhubaneswar, Institute of Minerals and Materials Technology (CSIR-IMMT), Bhubaneswar, National University of Singapore (NUS) & Nanyang Technological University (NTU), Singapore.

Institute of Physics (IoP), Bhubaneswar, Institute of Minerals and Materials Technology (CSIR-IMMT), Bhubaneswar, National University of Singapore (NUS) & Nanyang Technological University (NTU), Singapore, jointly organized the 12th India-Singapore Physics Symposium (ISPS 2019) at Toshali Sands, Puri during March 2-4, 2019. The Inaugural Ceremony of the Symposium was held on 2nd March, 2019 afternoon where Prof. Sudhkar Panda, Director, IoP, Prof. Sudhasatwa Basu (Director, CSIR-IMMT), Prof. B. V. R. Chowdari, NTU, Singapore and Prof. Mahendiran Ramanathan, NUS, Singapore were chaired the dais for the inaugural session. Dr. Debakanta Samal, IoP, the convener of the symposium introduce the dignitaries on the dais and all the members on the dais delivered their speeches on the symposium theme and threw lights on the aim of the symposium before the audience. Dr. S. N. Sarangi, IoP, Secretary of the Symposium coordinate the whole session and the inaugural session ends with vote of thanks given by Dr. Bikash Jena, CSIR-IMMT, Joint-Secretary of the symposium.

(Innagural session of 12th India-Singapore Physics Symposium (ISPS 2019) at Toshali Sands, Puri during March 2-4, 2019)

The technical program of the symposium consisting of 5 sessions was rich and varied with the major themes on novel magnetism and exotic super conductivity, strongly correlated and topological electron materials, complex oxidehetero-strucutures and interfacial phenomena, nanoscale/low-dimensional materials, 2D and energy materials, and advanced optical and electron spectroscopy. A total of 36 invited lecturers and about 25 poster presentations included in the whole symposium.

Among the dignitaries from Singapore, Prof. B. V. R. Chowdari, Prof. Cesare Soci, Prof. Fan Hongjin, Prof. Lu Bing Sui, Prof. Pinaki Sengupta, Prof. Ranjan Singh, Prof. Rainer Dumke, Prof. S. N. Piranayagam, Prof. Ariando, Prof. Andrivo Rusydi, Prof. Mahendiran Ramanathan, Prof. Venkatashamy Reddy, Prof. Wang Xuesen enlighten the audience with their excellent physics topics such as, Chalcogenide Metamaterials, Nanoarray electrodes for high-rate thin-film batteries, Novel Electrode electrode materials Design and Reaction mechanisms, STM studies of self-assembled nanostructures on graphite, Linear magneoresistance in $TmB_{4,}$ Casimir/van der Waals interaction between dielectrically, Anisotropic topological insulator slabs Interface-Engineering and Emergent Phenomena in, Oxide Heterostructure.

There was a poster session during March 3, 2019. Students and young researchers have presented their research work and a fruitful discussions were made among the faculties, scientists and students. Last session was concluded by Prof. B. V. R. Chowdari, Prof. Pinaki Sengupta, and Prof. Debakanta Samal by explaining the future of the Joint Singapore-India symposium and looking forward for the best use of this forum.

(Technical session of 12th India-Singapore Physics Symposium (ISPS 2019) at Toshali Sands, Puri during March 2-4, 2019)

OTHER ACTIVITIES

6.1 OutreachProgramme

6.1.1National Science Day Celebration-2019

The "National Science Day Celebration-2019" was conducted successfully on 28th February, 2019 in the Institute. Sri Bhupendra S. Poonia, IAS, State Project Director, Odisha Adarsha Vidyalaya Sanghthan, Govt. of Odisha was invited as a Chief Guest for the programme. About 200 students and 100 science teachers from different Odisha Adarsha Vidyalays across Odisha were participated in this programme. Prof. Niranjan Bairk, Prof. L. P. Singh, Ex-Professor of Physics, Utkal University, Dr. Gopal Chandra Pradhan, Asst. Professor, KIIT University, Dr. SatyaPrakash Sahoo, Reader-F, IOP, Dr. Arun Kumar Nayak, Reader-F, IOP and Dr. Debasmita Alone, Reader-F, NISER were invited as speakers for the programme. On 27.02.2019 evening two scientific popular lectures were arranged in the Institute Auditorium. About 250 participants were attended this programme. First Lecture was deliberated by Prof. L.P. Singh on "We and our Science" in Odia language. The second lecture was delivered by Prof. Niranjan Barik on "Our special place in the Universe" in Odia language.

The event was inaugurated by Sri Bhupendra S. Poonia, State Project Director, OAVS, Dr. Debakanta Samal, Convener, National Science Day Organising 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.

Dr. Gopal Candra Pradhan, KIIT University delivered invited talk on "Pursuit of Science: The C.V. Raman Way", Dr. Satyaprakash Sahoo, Institute of Physics delivered a talk on "Fundamental of Nanosciences", Dr. A. K. Nayak, Institute of Physics delivered a talk on "Understanding the fundamental constituents of matter" and Dr. Debasmita Alone, NISER deliver a talk on "Screening of Natural Products as anti-cancer agents".

The entire event provided a platform to the students & teachers to prove their talents, bring out their creativity and face the challenges and overcome their weaknesses through interaction with senior scientists of India. All participants known the significance of science day and the theme of this year's science day "Science for the people and people for the Science" and also the role ofscience and technology in our daily life. All the delegates as well as speakers elaborated the role of students in the development and progression of research in the field of science and technology to take up challenges at a higher level.

6.1.2 Sky watch Programme

Prof. A.M. Srivastava organized a night sky watch program with telescope for summer student visitors at IOP, 18th July, 2018.

6.1.3 National Scientific Temper Day

Prof. A. M. Srivastava organized a scientific program at IOP, Bhubaneswar on 20th Aug. 2018 for the celebration of this National Scientific Temper Day. The program was conducted jointly with scientists from Ravenshaw University, Institute of Mathematics and Applications, NISER, etc. About 200 students from class VIII to XII were invited from various schools in Bhubaneswar and Cuttack. The program consisted of two popular lectures, one relating to Scientific Temper, and the other on Detection of Gravitational Waves. The talks were followed by an extended one hour Open Discussion Session where students were encouraged to ask any question to a panel of scientists.

6.2 Activities of Official Language

6.2.0 OFFICIAL LANGUAGE IMPLEMENATION

Institute of Physics, Bhubaneswar is continued to carry out his activities to promote the use of Rajbhasha Hindi in various disciplines of research activities. Some of the efforts made in this direction are highlighted below:-

(Sri Makarand Siddhabhatti, Systems Manager is reading out the Message sent by Hon'ble Home Minister)

6.2.1 Celebration of Hindi Day-2018

Hindi Day was celebrated on 14.09.2018 in the Institute. During the celebration, the messages sent by the Minister of Home Affairs, Govt. of India and the Chairman, Atomic Energy Commission and the Secretary, Department of Atomic Energy regarding progressive use of Hindi were read out.

6.2.2 Celebration of Hindi Pakhwada-2018

With a view to create awareness and to increase the use of Hindi in official work, a 'Hindi Fortnight' was observed in the Institute during 10-25 September 2018. A number of competitions were held during the Fortnight, which were well taken by officers and staff of the Institute. As a

(A student of Ramadevi Womens' University receiving the certificate from Director of the Institute)

(Student of the Ravenshaw University is receiving the certificate from Prof. Sudhakar Panda, Director)

special case, two competitions were conducted for Post Graduate (Hindi) and Graduate (Hindi Hons.) students. About twenty students were participated from different Universities and Colleges situated in Bhubaneswar and Cuttack. Staff members and Students were given cash award and certificates for their excellent performances.

6.2.3 Organizing Joint Hindi Workshops.

Institute of Physics, Bhubaneswar, NISER and Heavy Water Plant, Talcher jointly organized the Hindi Workshop on 23.06.2018 on the title of "Contributory Health Service Scheme" and " Noting & Drafting and Hindi Vartani" in the Institute.

(Sri Samsen Vargeese, CAO, HWB (Left), Prof. S. Panda, Director (Center) and Sri R.K. Rath, Registrar on dais during the workshop)

A workshop on "Soft Skills" was organized on 03.07.2018 in the Institute. 14 members of the Institute participated in this workshop. Sri Anchaleswar Singh, Joint Director (OL), DAE, Mumbai was invited to deliver the lecture in the workshop.

For December, 2018 ending quarter, a joint Hindi Workshop organized at AEC School, OSCOM, and Chatrapur on 19.12.2018. The topic

(Dr. Ananda Kumar, Principal, AEC School, OSCOM, Chatrapur addressing the gathering)

of the workshop was "Official Language Policy and How to write correct Hindi". Participants from IOP, NISER, HWP, Talcher, OSCOM and AEC School, Chatrapur were participated in the workshop.

6.2.4 Celebration of World Hindi Day and Organizing Scientific Seminar in Hindi

The World Hindi Day-2018 and Scientific Seminar in Hindi organized on 10.01.2019 jointly with other six Scientific Institutes of the Bhubaneswar at ICAR-Central Institute of Freshwater Agriculture,

(Delegates during the inaugural function of the seminar)

Kausalyaganga, and Bhubaneswar. The subject of the seminar was "Role of Rajbhasha Hindi in Science Communication". 15 Nos. officials on behalf of the Institute were participated in this seminar.

6.2.5 All India DAE Hindi Translators Refresher Training Course

In collaboration with Administrative Training Institute, DAE, Mumbai, five days refresher course for All India DAE Hindi Translators was organized in the Institute during 08 to 12 October, 2018. In this training program 26 Nos. participants from different Units/Undertakings/Enterprises/Aided

(Delegates and Chief Speaker during the inauguration of the training programme)

(Delegates, Faculty Members & participants during the "Valedictory function" of the training programme)

Institutions across the India participated in the training programme. Dr. R. B. Singh, Ex-Deputy Director, Central Translation Bureau, Govt. of India was invited as Faculty Member for the training programme.

6.2.6 Town Official Language Implementation Committee Meeting

(The Secretary, TOLIC (left), Guest of Honour (Central) and Chief Guest addressing the gathering during the meeting)

64th Town Official Language Implementation Committee (Central), Bhubaneswar meeting was arranged in the Institute on 19.02.2019.

6.2.7 Winning of DAE Rajbhasha Shield

Institute of Physics, Bhubaneswar has been awarded with "Rajbhasha Shield" for the year of 2018 by the Department of Atomic Energy for its excellent implementation of the official language

(Prof. Sudhakar Panda, Director is receiving "Rajbahasha Shield "from Sri A.R. Sule, Chairman, OLIC, DAE)

Hindi in the Institute. This award was given on 02.02.2019 during the All India Official Language Conference held at NISER, Jatani, Odisha.

6.2.8 Winning of DAE Hindi Sevi Samman

Sri Makaranda Siddhabhatti, System Manager of the Institute was honored with 'Hindi Sevi Samman" for the year of 2018 on 02.02.2019 during All India DAE Official Language Conference at NISER.

(Sri M. Siddhabhatti is receiving "Hindi Sevi Samman")

6.3. International Day of Yoga-2018

The 4th International Yoga Day was celebrated with great enthusiasm in the Institute on June 21st, 2018. Yogasana and Pranayam were performed under the guidance of learned yoga expert Dr. Biswaranajan Rath, Dev Sanskrit Yoga Bidyalaya, Bhubaneswar in which staff members and scholars were participated. Dr. Rath was delivered a lecture on "Yoga" and conducted an interactive session on Yoga and its benefits for the mankind. A separate programme was arranged at the Institute where Prof. Sudhakar Panda, Director and Sri R.K. Rath, Registrar were also participated.

(During the occasion of the International Day of Yoga-2018)

6.4. "Swachhata Hi Seva" Program

Institute of Physics carried out various programmes under Swachhata Hi Seva 2018 during 26.09.2018 to 02.10. 2018 as a precursor to the launch of 150th birth anniversary celebrations of Mahatma Gandhi and in the run up to the 4th anniversary of Swachha Bharat Mission. A cleanliness activity was organized near the all building of the office by all the staff. Discussion, awareness programmes and lectures on SHS were also arranged.

(Cleaning activities during the Swachhata Hi Seva Week)

6.5. Sports activity for the year 2018-19

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 members of IOPEWS are Dr. Suresh Kumar Patra(President), Dr. Arjit Saha, Sri J. K. Mishra, Sri B. k. Dash(Sport's convener), Smt A. Kujur, Sri P. Patra, Sri R. Mahapatra, Sri B. Mohanty (Cultural convener), Sri B. Behera (Secretary).

Followings are the different activities conducted during the year 2018-19:

1. A Football match was conducted on 15th August, 2018. This was a friendly match between Director's Team (Faculties and Doctoral) and Registrar's Team (Staffs of theInstitute). Registrar's

Team won the match. Around 110 spectators were there to enjoy the football match.

2. A friendly Cricket match was also conducted on the occasion of 26th January, 2019. This match was played between Director's Team (Faculties & Doctoral) and Registrar's Team (Staffs). Registrar's Team won the match. It was a very interesting match. Around 80-viewers joined and made the event successful.

3. Institute also organized the Annual Sports and Cultural Meet in the month of November, 2018. These events started on 12.11.2018 and got completed on 25.11.2018. The total number of events was 17. Around 55 staff members participated in men's events, 30 family members participated in the women's events, and 40 children participated in children's event. Among staffs, 20 volunteers coordinated for a successful completion of the Annual day. The winners of different events were awarded in the Annual day program. Also few staffs were rewarded, those who had completed 25 years of service in IOP.

The photos of IOP Annual sport's program

6.6. Fire Service Week 2018

The "Fire Service Week" was celebrated in the Institute from 14.04.2018 to 20.04.2018. Several programmes were organized by Fire Safety Committee, IOP during the Fire Service Week to create fire awareness among the employee in IOP and the residents at Colony. Sri M. Swain, Principal, OFDRA, Bhubaneswar inaugurated the "Fire Service Week-2018" programme on 14.4.2018. Fire Fighting & Rescue demonstration in a high rise building was held at Administrative Extension building of the Institute.

(Sri S. K. Sahu, Prof. B.R. Sekhar and Sri R.K. Rath at Dias and Sri M. Swain delivering the lecture on "Inauguration Programme)

6.7. Other Activities Observed in the Institute

6.7.1 Vigilance Awareness Week-2018

As per the directives of Central Vigilance Commission "Vigilance Awareness Week" is observed every year. Accordingly, "Vigilance Awareness Week-2018" was observed in the Institute during 29th October to 3rd November, 2018 on the theme of "Eradication Corruption-Building a New India". The week commenced with administering integrity pledge by Director of the Institute to all Staff Members and Students on 29.10.2018. During the week various programmes such as Handouts, posters were distributed among the staff members and displayed on the different places of the Institute.

6.7.2. International Labour Day-2018

The International Labour Day was celebrated on 1st May, 2018 in the Institute. The function started with a Special Assembly by 16 workers working the Institute. Sri R. K. Rath, Registrar

congratulated the workers and thanked them for their selfless services. Sri T. K. Panda, Deputy Chief Labour Commissioner (Central), Govt. of India, Bhubaneswar was Chief Speaker of the event and he highlighted the historical events that contributed to the emergence of labour rights and the significance of the day in the present time. He advised the workers to spare some valuable time for themselves and play some games so that they get rejuvenated and remain positive and vibrant.

6.7.3. Independence Day Celebration-2018

Independence Day was celebrated with great enthusiasm and respect at Institute. The ceremony started at 7.00 AM in the Institute open ground with large crowd of staff, students and family members. Prof. Sudhakar Panda, Director was escorted by the Security Personnel of the Institute. To

(Prof. Sudhakar Panda, Director during the Guard of Honour on the occasion of Independence Day Celebration-2018)

commemorate the sovereignty of our nation, Prof. Panda unfurled the tricolor flag and all in unison sang the National Anthem and expressed the joy of our freedom.

6.7.4. Celebration of Institute of Physics Employees Welfare Society Foundation Day

Institute of Physics Employees Welfare Society celebrated its 3rd Foundation Day on 1stJanuary, 2019 in the Institute. Prof. Sudhakar Panda, Director as a Chief Guest, Sri R. K. Rath, Registrar Prof. S. K. Patra, President and Sri Bhagaban Behera, General Secretary of the Society were present in the function.

Members of the Society as well as their family members also were participated in this function.

(Prof. Sudhakar Panda, Director distributing the prizes to the winners)

(Prof. Panda and Sri. R.K. Rath, Registrar with the Institute family members during the function)

Prof. Panda presented the prizes to different winners of the various competitions organized in the Institute.

6.7.5. Republic Day Celebration

Institute of Physics, Bhubaneswar celebrated the 70th Republic Day on the 26th January, 2019. Faculty Members, Staff, Scholars and their family members filled with a feeling of patriotism and dedication gathered in front of the Administrative Building. The celebration started with the hoisting of the National Flag by the Registrar Sri R.K. Rath followed by the National Anthem. In his speech in Hindi, he highlighted the importance of the Constitution and its unique features. The program ended

with the message to create a great nation through collective efforts from all individuals. Sweets were distributed among the gatherings.

6.7.6. SPIC MACAY ODISHA CHAPTER

On 27/10/2018, The SPIC MACAY Odisha Chapter organised its second overnight concert at IOP auditorium. The Musical concert was attended by more than 400 audience which includes students from nearby colleges, local dignitaries and people from IOP. The founder of SPIC MACAY, Padma Shri Prof Kiran Sheth was present throughout the concert which made the event an important one. The various renounced artists who performed at the above concert are following. The program started with the mesmerizing performance of Ghatam by Padma Bhushan Bidwan Vikku Vinakram and his associates. This was followed by wonderful Sitar performance by Shri Purbyan Chatterjee. Next performance was done by Vidushi Ashwini Bhide Deshpande followed by Ustad Sabor Khan in Sarangi. The Program ended with Hindustani Voval performance by Ustad Raja Miyan. Throughout the concert, the audience was always alive and participating the master on the stage whenever asked. All the arrangement and cooperation by IOP staff was flawless. The event was sponsored by

OMC, NALCO, MCL, TATA STEEL, ODISHA TOURISM, ODISHA LIVE, outdoor partner TEAM.

ଶାସ୍ତ୍ରୀୟ ମହୋତ୍ସବ 'ଯାମିନୀ-୨୦୧୮'

ଭୁବନେଶ୍ୱର, ୨୭/୧୦ (ଇମିସ): ଭାରତୀୟ ଶାସ୍ତ୍ରୀୟ ସଙ୍ଗୀତ ଓ ସଂସ୍କୃତିକୁ ଯୁବପିଢ଼ିଙ୍କ ମଧ୍ୟରେ ପ୍ରଚାର ଓ ପ୍ରସାର ଉଦ୍ଦେଶ୍ୟରେ କାର୍ଯ୍ୟରତ 'ସ୍ପିକ୍‌ମାକେ' ଅନୁଷ୍ଠାନ ପକ୍ଷରୁ ଆଜି ଶାସ୍ତ୍ରୀୟ ମହୋତ୍ସବ 'ଯାମିନୀ-୨୦୧୮' ଆରମ୍ଭ ହୋଇଛି। ସ୍ଥାନୀୟ ପଦାର୍ଥ ବିଜ୍ଞାନ ପ୍ରତିଷ୍ଠାନରେ ଅନୁଷ୍ଠିତ ଏହି କାର୍ଯ୍ୟକ୍ରମରେ ଅନୁଷ୍ଠାନର ପ୍ରତିଷ୍ଠାତା ଅଧ୍ୟକ୍ଷ ଜିଉଣ ସେଠ୍, ଅଧ୍ୟକ୍ଷ ଅରୁଣ ସାହା ଓ ଅଶୋକ କୁମାର ତ୍ରିପାଠୀ ମୁଖ୍ୟ ଅତିଥି ଭାବେ ଯୋଗଦେଇ କାର୍ଯ୍ୟକ୍ରମକୁ ଉଦ୍‌ଘାଟନ କରିଥିଲେ। ଏହି ଅବସରରେ ପଦ୍ମବିଭୂଷଣ ପଣ୍ଡିତ ଭିକୁବିନାୟକରାମ୍ ଘଟମ୍ ବାଦ୍ୟ ଯନ୍ତ୍ରରେ ଶାସ୍ତ୍ରୀୟ ସଙ୍ଗୀତ ପରିବେଷଣ କରିଥିବା ବେଳେ ସିତାରରେ ପୂର୍ବାୟନ ଚାଟାର୍ଜୀ, ସାରଙ୍ଗୀରେ ଉସ୍ତାଦ ସବିର ଖାନ୍ ଓ ଉସ୍ତାଦ ରାଜା ମିଆଁ, ବିଦୁଷୀ ଭିଡ଼େ ଦେଶପାଣ୍ଡେ ହିନ୍ଦୁସ୍ତାନୀ ଶାସ୍ତ୍ରୀୟ ସଙ୍ଗୀତ ପରିବେଷଣ କରିଥିଲେ। ସୁର ଓ ତାଳର ଏକ ଅପୂର୍ବ ସଙ୍ଗମରେ ଉପସ୍ଥିତ ଶ୍ରୋତା ଶ୍ରୋତା ବିମୋହିତ ହୋଇଥିଲେ। ଏହି କାର୍ଯ୍ୟକ୍ରମ ଆଜି ସଂଧ୍ୟା ୬ଟା ୩୦ରୁ ଆରମ୍ଭ ହୋଇ ରାତିବାର ପାଖାପାଖି ୬ଟା ପର୍ଯ୍ୟନ୍ତ ଚାଲିବ। ସୁଲିମାନ୍ ଦୌଇଜୀ ସ୍ୱାଗତ ଭାଷଣ ଦେଇଥିବା ବେଳେ ରବିତା ମିଶ୍ର କାର୍ଯ୍ୟକ୍ରମକୁ ପରିଚାଳନା କରିଥିଲେ। ଶୁଭା ଦାସ ଓ ଗିରିଜେଶ୍ୱର ନାୟକ ପ୍ରମୁଖ କାର୍ଯ୍ୟକ୍ରମକୁ ସଂଯୋଜନା କରିଥିଲେ।

'ସ୍ପିକ୍‌ମାକେ'ର ବିନିଦ୍ରା ରଜନୀ ସଙ୍ଗୀତ ବିଚିତ୍ରା 'ଯାମିନୀ'

ବାଦ୍ୟଯନ୍ତ୍ର ଓ ଶାସ୍ତ୍ରୀୟ ସଙ୍ଗୀତର ସମନ୍ୱୟ

Local hospitality and food was arranged by IOP and a monetary assistance of Rs 20000/- only was provided toward the event.

6.7.7. WOMEN CELL ACTIVITIES

Awareness Meeting for Women Members at IOP was held on 21 May 2018 in the main lecture hall. In the meeting Prof. Shikha Varma and Prof. Manimala Mitra presented various issues concerning the welfare of women on IOP campus. The awareness meeting was especially planned to bring to the

notice of all the members present, especially summer students and scholars, various avenues and redressal mechanisms existing, in IOP, to address any sexual harassment complaints or related grievances. The constitution of Women Cell, IOP, was described. Members also discussed the background and reasons behind the creation of a Women Cell, in any institution, and its mandate to prevent or deter the commission of acts of sexual harassment and to provide the procedures for the resolution, settlement or prosecution of acts of sexual harassment by taking all steps required. One of the main responsibility of the cell is to deal with cases of sexual harassment, in a time bound manner, aiming at ensuring support services to the victimized and termination of the harassment. The role of women cell also involves making recommendations for developing a conducive atmosphere on the campus, where women can work safely with dignity and without any discrimination. There was an extensive discussion during the meeting. Women scholars and some other members had queries regarding the complaint and redressal mechanisms. Various suggestions came from the members and these were communicated to the Director. Some suggestions included more such meetings as well as starting discussion groups of such activities.

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

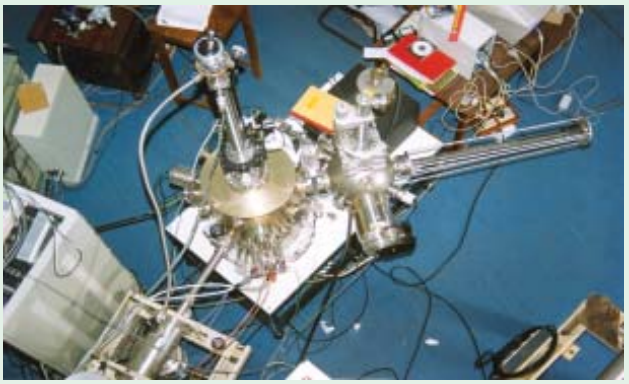
heavy ions (carbon or above) is 3+ for terminal potentials above 2 MV.

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

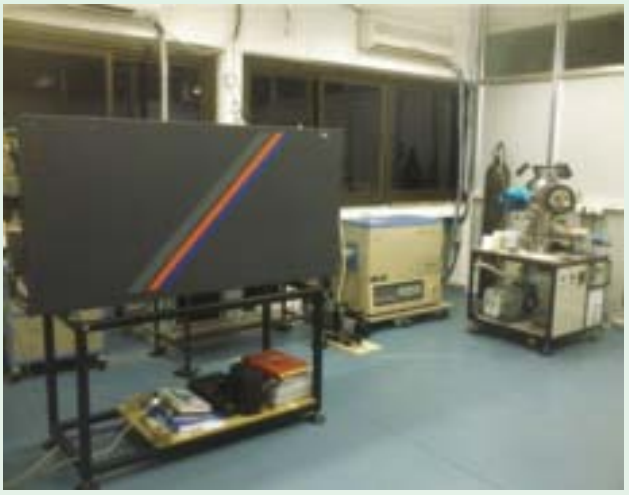
The Angle Resolved Ultraviolet Photoelectron Spectrometer (ARUPS) is equipped with facilities for doing both angle integrated valence band measurements as well as angle

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

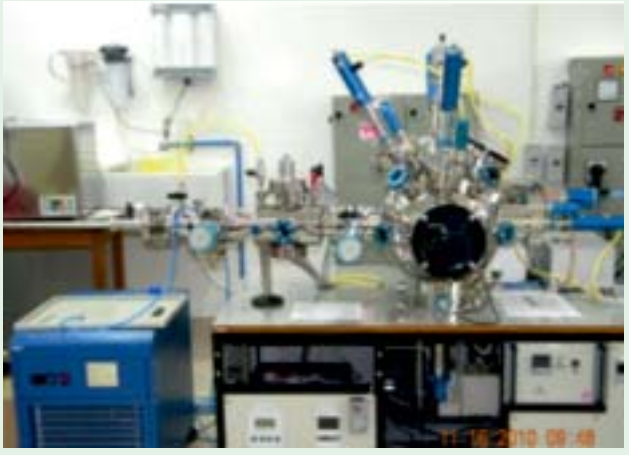
Pulsed Laser Deposition (PLD) System

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

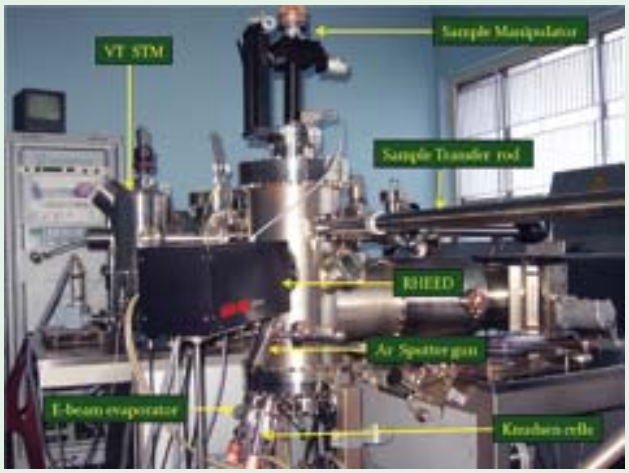


dedicated to operate with pulsed DC supply and the other two are connected to RF power supply. The substrate is made to rotate during film deposition towards having high-quality uniform films. One can put the substrate holder at a high temperature (up to 6000 C) for film growth at elevated temperatures. 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 MEASURE-MENT 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

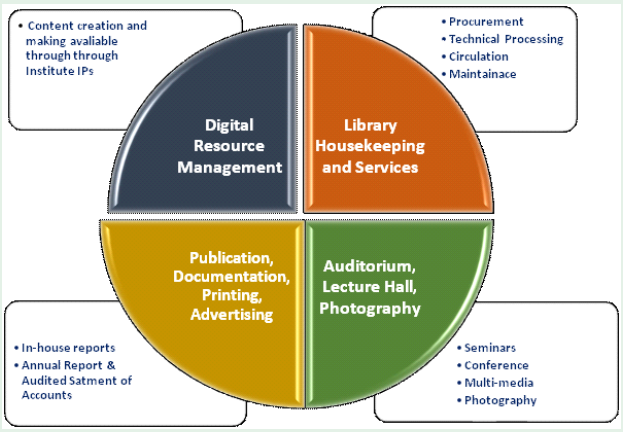
Institute of Physics is a node on ANUNET with the provision to connect other units of DAE directly by VSAT link for voice and data communication. Seismic monitoring equipment has been installed in the Institute and seismic data is being continuously transmitted to Bhabha Atomic Research Centre (BARC)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

IOP Library broadly has two sections namely IOP Resource Centre and IOP General Library. The mandate of IOP Resource Centre is to select, acquire, process and disseminate both print and electronic/digital scientific & technical resources for the information needs of research community of the Institute along with stakeholders of other associated organization in a right time and right possible ways. 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 essential Library services, IOP Library also provides allied facilities namely reprography, printing, publishing, advertising, photography, videography, document delivery, and auditorium with lecture hall services. Apart from these, other related activities like conducting conferences/ seminars, outreach programs are also being taken care of by IOP Library.



The Library facility is available to the members of the Institute as well as members from other academic institutions. 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 consists 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). Apart from the Academic [*research papers/thesis/case study/review etc.*], this tool can also be used for Official/ Business/ Technical noting and drafting for checking Grammar, Punctuation, Sentence Structure, Style and many more. The toolcan be accessed through the library portal.

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, 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 PAPERS PUBLISHED IN JOURNALS:

1) Mohanty, B., Sahoo, J., and Dash, N. K. (2018). Bibliometric Indicators for Assessing the Quality of Scholarly Communications: A Case Study on International Journal of Cooperative Information Systems, Library Philosophy and Practice, *(e-journal)*. Paper 2158. http://digitalcommons.unl.edu/libphilprac/2158 .

2) Sahoo, J., **Mohanty, B.** and Dash, I. (2018). An Analytical Study on the Publication Pattern and Impact of Top Research Papers: A Case Study of Information Processing and Management, *Library Philosophy and Practice (e-journal)*. Paper 2090. Available at http://digitalcommons.unl.edu/libphilprac/2090/ .

PUBLICATIONS OTHER THAN RESEARCH PAPERS:

3) Sahoo, J., Sahu, S. C. and **Mohanty, B.** (2018). *Open Access Scholarly Communications in Knowledge Economy: A Case study of Web of Science in Knowledge Organisation* in Academic Libraries (I-KOAL-2018) in Proceedings of International Conference, 26-27 November, 2018, University of Hyderabad jointly organised by Library Professionals Association, New Delhi.

4) Dash, N. K., Sahoo, J., **Mohanty, B.** and Padhi, P. (2018). *Users' Perceptions on Library Services: A Qualitative Study through Comment Analysis* in International Conference on Marching Beyond Libraries: Managerial Skills & Technological Competencies;16-17 November, 2018, Bhubaneswar: KIIT University & Overseas India Pvt. Ltd.; ISBN – 978-81-938797-1, pp. 392-402.

5) Sahoo, J., **Mohanty, B.,** Ratha, L., Meher, A., & Sahu, J. K. (2018). *Massive Open Online Courses and MOOCs-SWAYAM: An Assessment of Acceptance*. In A. Kaushik (Ed.), *Library and Information Science in the Age of MOOCs* (pp. 66-81). Hershey, PA: IGI Global. doi:10.4018/978-1-5225-5146-1.ch004

7.6 AUDITORIUM:

We have an auditorium in our campus where we organize 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

Prof. Sudhakar Panda

Director and Sr. Professor

Theoretical High Energy Physics

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
   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
   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. Dr. Goutam Tripathy
    Reader-F
    Condensed Matter Physics (Theory)
12. Prof. Pradip Kumar Sahu
    Associate Professor
    Nuclear Physics (Theory)
13. Dr. Dinesh Topwal
    Reader - F
    Condensed Matter Physics (Experiment)
14. Dr. Sanjib Kumar Agarwalla
    Reader - F
    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. Paramita Dutta (Joined on 1st August, 2016 under Prof. A. M. Jayannavar)
2. Shidharth S. Ram (Joined on 4th April, 2017 under Prof. P. V. Satyam)
3. Ravi K. Bomali (Joined on 1st July, 2017 under Dr. D. Topwal)

8.3. Post-Doctoral Fellows

1. Dr. Subhajit Sarkar
2. Dr. Sk. Firoz Islam
3. Dr. Sangram Keshari Das
4. Dr. Shakti Shankar Acharya
5. Dr. Chaitra S. Hegde
6. Dr. Bhaskara Chandra Behera
7. Dr. Mruganka Mouli Mandal
8. Dr. Soumya C
9. Dr. Tapoja Jha
10. Dr. Minati Biswal
11. Ravi Kumar Bomali
12. Nirakar Sahoo
13. Biplab Bhattacahrjee
14. Sudheer
15. Sitendra Pratap Kashyap
16. Manpreet Kaur
17. Jaspal Singh
18. Satyaki Kar

8.4. Research Assistant

1. Arpan Das
2. Ashis Kumar Manna
3. Bharat Kumar
4. Chandan Datta
5. Debasish Saha
6. Mahesh Saini
7. Paramita Maiti
8. Pronoy Nandi
9. Ranveer Singh

8.5. Doctoral Scholars

1. Bibhabasu De
2. Chinmaya Kumar Panda
3. Diwakar
4. Pranjal Pandey
5. Rupam Mandal
6. Saiyad Ashanujjaman
7. Rojalin Padhan
8. Rahul Roy
9. Gupteswar Sabat,
10. Abhisek Bag
11. Avnish
12. Debjyoti Majumdar

13. Sayan Jana
14. Subhadip Jana
15. Vinaykrishnan M.B.
16. Sudarshan Saha
17. Alapan Dutta
18. Amir Shee
19. Atanu Maity
20. Dibyendu Rana
21. Dilruba Hasina
22. Amit Kumar
23. Biswajit Das
24. Ganesh Chandra Paul
25. Partha Paul
26. Sujaya Shil
27. Vijigiri Vikas
28. Amina Katun (INO Proj. Student)
29. Honey Khindri (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. Bhagaban Behera
3. Baula Tudu
4. Saubhagya Laxmi Das
5. Ghanashyam Pradhan
6. Samarendra Das
7. Gokuli Charan Dash

(iv) Stores & Transport

1. Sahadev Jena
2. Pramod Kumar Senapati
3. Sadananda Pradhan
4. Sanatan Jena
5. Sarat Chandra Pradhan
6. Jahangir Khan
7. Keshaba Chandra Daku

(v) EPABX

1. Arakhita Sahoo
2. Ghanashyam Naik

(vi) Despatch

1. Krushna Chandra Sahoo

(vii) Accounts

1. Ranjan Kumar Nayak
2. Jitendra Kumar Mishra
3. Bhaskara Mishra
4. Prativa Choudhury
5. Sahadev Jena
6. Priyabrata Patra
7. Rajesh Mohapatra
8. Jyoti Ranjan Behera
9. Chandramani Naik
10. Bansidhar Panigrahi

(viii) Maintenance

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

7. Purna Ch. Maharana
8. Sajendra Muduli
9. Pabani Bastia
10. Rabi Narayan Mishra
11. Umesh Ch. Pradhan
12. Gandharba Behera
13. Biswa Ranjan Behera
14. Kapila Pradhan
15. Martin Pradhan
16. Chandra Mohan Hansdah

(ix) Estate Management

1. Saroj Kumar Jena.
2. Gangadhar Hembram
3. Tikan Kumar Parida
4. Banamali Pradhan
5. Biswanath Swain
6. Bijoy Kumar Swain
7. Bijoya Kumar Das
8. Babuli Naik
9. Sanatan Pradhan
10. Bhaskara Mallick
11. Kulamani Ojha
12. Pitabas Barik
13. Dhoba Naik
14. Charan Bhoi
15. Jatindra Nath Bastia
16. Basanta Kumar Naik
17. Daitari Das
18. Ramesh Kumar Patnaik

(x) Library

1. Dr. Basudev Mohanty
2. Dillip Kumar Chakraborty
3. Ajita Kumari Kujur
4. Rama Chandra Hansdah
5. Rabaneswar Naik
6. Kisan Kumar Sahoo
7. Kailash Chandra Jena
8. Pradip Kumar Naik

(xi) Computer Centre

1. M. Shidhabatti
2. Nageswari Majhi

(xii) Laboratory

1. Sanjib Kumar Sahu
2. Anup Kumar Behera
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

(xiii) Workshop

1. Subhabrata Tripathy
2. Ramakanta Nayak
3. Rabi Narayan Naik

(xiv) Purchase Section

1. Aviram Sahoo
2. Raj Kumar Sahoo

8.7. LIST OF RETIRED MEMBERS

Name: Shri Ranjan Kumar Nayak
Designation: Accounts Officer
DoJ: 12.09.2005
DoR: 30.04.2018

Name: Shri Rabi Narayan Mishra
Designation: Tradesman-D
DoJ: 08.04.1982
DoR: 30.04.2018

Name: Shri Chandramani Naik
Designation: Tradesman-C
DoJ: 19.09.1979
DoR: 31.05.2018

Name: Shri Sadananda Pradhan
Designation: Driver cum Supervisor
DoJ: 09.10.1979
DoR: 30.06.2018

Name: Shri Sajendra Muduli
Designation: Tradesman-F
DoJ: 10.07.1992
DoR: 31.07.2018

Name: Shri Rabeneswar Naik
Designation: Tradesman-D
DoJ: 10.10.1983
DoR: 31.10.2018

Name: Shri Gokuli Chandra Dash
Designation: MTS-B
DoJ: 17.10.1992
DoR: 31.12.2018

Name: Shri Krushna Chandra Sahoo
Designation: Upper Division Clerk
DoJ: 12.04.1982
DoR: 28.02.2019

Name: Dr. Amitabh Virmani
Designation: Reader-F
DoJ: 13.12.2012
DoR: 01.08.2017

परीक्षित लेखा विवरण

AUDITED STATEMENT OF ACCOUNTS
2018-19

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 AUDIT'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 2019 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.

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

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E-mail : parthamishra1@yahoo.com / psmefiling@gmail.com / psm_caoff@rediffmail.com

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. E- Journals have been capitalized as tangible assets and depreciated for the whole year. E- Journals are paid in calendar yearly basis but the whole years E-journals have been capitalized thus contravening the provisions of the AS10 and AS-6. The depreciation on assets purchased during the year was also charges for the whole year instead of proportionate basis from date to use.

   The interest from STDR given against Letter of credit should not be deducted from the cost of fixed Assets but should be shown as "Income from Other Sources".

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 matters:

1. The lease deed for 50 acres of land at Mouza Nayapalli is not available. However, the copy of the land allotment letter and possession letter ware available in the file. Lease records in respect of 6.130 acres was available. The ROR Shows that the 47.32 Acre land belongs to Education Department, Govt. of Odisha. So Institute of physics must take necessary steps to mutate the schedule land in its favor.
2. Balances of advances and liabilities recognized from third Parties are subjects to confirmation.

We are not qualifying our report on the above points.

3ased 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, 2019
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

P.S. Mishra (FCA, DISA)
Partner, M. No.-060108

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 2018-19

1) Maintenance of books of accounts:
The following manual books of accounts are maintained in the year 2018-19
   a) Cash cum bank book
   b) Cheque issue register
   c) Staff advance register
   d) Security deposit register
   e) TDS register

2) Cash and bank:
   a) In some cases the institute has paid cash above Rs. 10000 to visiting scientists/ Employees. Instances are given below:

Date	Particulars	Voucher No	Amount(Rs.)
29/06/2018	Honorarium paid to Ashok Das	CP 25	70,000
31/07/2018	Honorarium paid to Ashok Das	CP 34	70,000
28/02/2019	Science Outreach Activities	CP 94	2,68,028

   b) The institute has operated 27 nos. of bank accounts. All banks have been reconciled.

3) 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	22/01/2019	Dr. Shikha Varma	Foreign Travel	1,20,000.00
3	30/03/2019	Dr. Dinesh Topwal	Laboratory	10,714.40

   b) The STDR aginst L/C are pending as on 31.03.2019 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	Oxford instruments Nano Analysis,UK	29.09.2015	7,74,540
2	Testronix Asia Ltd,USA	27.04.2018	3,70,833
3	Twente Solid State Technology,The Netherlands	02.05.2018	37,37,650
4	LakeShoreCryotronicsinc,USA	30.04.2018	4,14,970
5	DanfysikAS,Denmark	07.03.2019	63,00,000
6	Heidelberg instruments Mikrotechnik,Germany	07.03.2019	1,04,00,000

c) During the course of audit, it is noted that a sum of Rs.4,07,776 is due as on 31st March 2019. Details are as given below.

Sl No	Date	Ledger Name	Amount(Rs.)
1	30/03/2019	GST Payable (Plan)	51,450
2	28/02/2019	Gratuity Payable	2,87,123
3	30/03/2019	TDS Payable (Plan)	43,190
4		NPS Payable	26,013
		TOTAL:	**4,07,776**

d) Fixed Asset Register: - During the course of audit, it is observed that IAS-10 and AS 6 regarding to fixed assets and deprecation respectively, have not been complied with. Further, since fixed asset register was not being maintained by the institute, we are unable to comment over the physical location and working condition of the asset.

Further, depreciation is being charged on gross block even in cases where the assets has been fully depreciated.

E journal expenses are being written off in the year when the same was subscribed to. However the same should be bifurcated on a proportionately based on the number of months for which the subscription was active in the financial year.

e) Leasehold Property: - The lease deed for 50 acres of Land at MouizaNayapalli is not available for verification; however the Land allotment and possession letter was available for verification. As per lease record the area was 6.130acre, however as per ROR shows that 47.32 acres land belong to Education Department, Govt of Odisha. So Institute of Physics must take necessary actions to mutate the scheduled land in its favor.

For PARTHA S. MISHRA & CO.
Chartered Accountants

P.S. Mishra (FCA, DISA)
Partner, M. No.-060108

INSTITUTE OF PHYSICS, BHUBANESWAR

BALANCE SHEET AS AT 31ST MARCH 2019

(Amount - Rs.)

CORPUS/ CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year
CORPUS/ CAPITAL FUND	1	60,45,43,580	69,71,21,502
RESERVES AND SURPLUS	2	-	-
EARMARKED/ ENDOWMENT FUNDS	3	90,84,957	1,14,84,655
SECURED LOANS AND BORROWINGS	4	-	-
UNSECURED LOANS AND BORROWINGS	5	-	-
DEFFERED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	18,71,95,602	17,23,08,774
TOTAL		**80,08,24,139**	**88,09,14,931**
ASSETS			
FIXED ASSETS	8	73,96,15,867	76,98,16,547
INVESTMENTS FROM EARMARKED/ ENDOWMENT FUNDS	9	-	-
INVESTMENTS OTHERS	10	-	-
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	6,12,08,272	11,10,98,384
TOTAL		**80,08,24,139**	**88,09,14,931**
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

P.S. Mishra (FCA, DISA)
Partner, M. No.-060108

Place : Bhubaneswar
Date : 09-09-2019

रजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

STATEMENT OF INCOME AND EXPENDITURE FOR THE PERIOD/YEAR ENDED 31ST MARCH 2019

(Amount - Rs.)

INCOME	Schedule	Current Year	Previous Year
Income from sale or services	12	-	-
Grants/ Subsidies	13	33,10,00,000	38,96,00,000
Fees/ Subscriptions	14	-	-
Income from investments	15	-	-
Income from royalty, Publication etc	16	-	-
Interest Earned	17	4,39,362	3,76,413
Other Income	18	28,91,284	37,37,940
Increase decrease in stock of finised goods/ WIP	19	-	-
TOTAL (A)		**33,43,30,646**	**39,37,14,353**
EXPENDITURE			
Establishment Expenses	20	23,21,48,978	21,37,68,299
Other Administrative Expenses etc.	21	7,23,42,928	8,16,47,284
Expenditure on grants Subsidies etc (Plan grant Surrendered)	22	-	-
Interest Paid	23	-	-
Depreciation (Corresponding to Schedule 8)		12,24,16,661	11,66,42,121
TOTAL (B)		**42,69,08,567**	**41,20,57,704**
Balance being excess of Expenditure over Income (B-A)		(9,25,77,921)	(1,83,43,351)
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/ CAPITAL FUND		**(9,25,77,921)**	**(1,83,43,351)**
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

Place : Bhubaneswar
Date : 09-09-2019

P.S. Mishra (FCA, DISA)
Partner, M. No.-060108

रजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

निदेशक/DIRECTOR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 1 - CORPUS/CAPITAL FUND				
Balances as at the beginning of the year		69,71,21,501		67,45,86,853
Add : Contributions towards Corpus/Capital Fund	-		4,08,78,000	
Add/(Deduct) : Balance of Income/(Expenditure) transferred from Income & expenditure Account	(9,25,77,921)	(9,25,77,921)	(1,83,43,351)	2,25,34,649
Balances as at the year end		**60,45,43,580**		**69,71,21,502**

PARTHA S. MISHRA & CO. Chartered Accountants

REGISTRAR
INSTITUTE OF PHYSICS
BHUBANESWAR

निदेशक / DIRECTOR
भौतिकी संस्थान / INSTITUTE OF PHYSICS
भुवनेश्वर / BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

(Amount - Rs.)

	Current Year				
SCHEDULE 3 - EARMARKED/ENDOWMENT FUNDS	OB	Receipt	Payment	CB	Previous Year
1. L. K. Panda Memorial Fellowship	2,10,392.00	12,149.00	5,000.00	2,17,541.00	2,10,392.00
2. TPSC Account	22,837.00	81,784.00	96,032.00	8,589.00	22,837.00
3. Inspire Grant of Dr. S.K.Agarwalla	3,92,465.00	11,789.00	3,87,848.00	16,406.00	3,92,465.00
4. Inspire Grant of Dr. Manimala Mitra	7,36,779.00	25,660.00	2,46,930.00	5,15,509.00	7,36,779.00
5. NPDF of Dr. S. S. Ram	1,79,024.00	9,13,888.00	8,24,030.00	2,68,882.00	1,79,024.00
6. NPDF of Dr. R. K. Bommali	4,17,647.00	8,98,609.00	4,47,179.00	8,69,077.00	4,17,647.00
7. NPDF of Dr. P. Dutta	98,727.00	2,52,046.00	3,10,175.00	40,598.00	98,727.00
8. JC Bose Grant of Prof. S. Panda	15,47,863.00	4,38,479.00	19,86,342.00	-	15,47,863.00
9. JC Bose Grant of Prof. A. M. Jayannavar	92,250.00	14,20,192.00	6,53,774.00	8,58,668.00	92,250.00
10. JC Bose Grant of Prof. S. M. Bhattacharjee	8,71,433.00	8,69,151.00	14,39,975.00	3,00,609.00	8,71,433.00
11. Ramanujan Fellowship Grant of Dr. A. K. Nayak	4,15,099.00	5,11,836.00	5,34,654.00	3,92,281.00	4,15,099.00
12. INSA Grant of Prof. J. Maharana	1,14,980.00	3,57,176.00	4,72,156.00	-	1,14,980.00
13. BI IFCC Grant of Dr. P. K. Sahu	21,68,983.00	53,559.00	15,53,562.00	6,68,980.00	21,68,983.00
14. UGC-CSR Grant	2,11,886.00	6,591.00	34,233.00	1,84,244.00	2,11,886.00
15. Woman Scientist Grant of Dr. S. Bandopadhyay	1,58,839.00	4,182.00	85,856.00	77,165.00	1,58,839.00
16. DST Grant of Prof. S. Varma	3,91,709.00	12,097.00	1,15,591.00	2,88,215.00	3,91,709.00
17. SERB Grant of Dr. D. Chaudhuri	12,04,063.00	24,113.00	11,99,100.00	29,076.00	12,04,063.00
18. Max-Plank Grant of Dr. D. Samal	22,02,390.00	16,77,512.00	12,67,912.00	26,11,990.00	22,02,390.00
19. DRDO Project	25,430.00	1,016.00	26,446.00	-	25,430.00
20. Fly Ash Utilisation Programme	4,701.00	175.00	4,876.00	-	4,701.00
21. CSIR Pool Scientist Programme	7,288.00	258.00	-	7,546.00	7,288.00
22. Indo-Japan S&T Co-operation	9,870.00	363.00	10,233.00	-	9,870.00
23. INSA Young Scientist - SK Agarwalla	-	5,09,033.00	3,02,583.00	2,06,450.00	-
24. NALCO Project - PV Satyam	-	21,21,797.00	5,98,666.00	15,23,131.00	-
TOTAL:	1,14,84,655.00	1,02,03,455.00	1,26,03,153.00	90,84,957.00	1,14,84,655.00

REGISTRAR

DIRECTOR
INSTITUTE OF PHYSICS
BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS:				
A. CURRENT LIABILITIES				
1. Statutory Liabilities:				
NPS Recovery Payable	26,013		1,44,449	
Professional Tax Payable	(325)		400	
TDS Salary Payable	67,490		24,80,604	
TDS Non-Salary Payable	13,588		41,430	
Plan GST Payable	51,450		-	
Plan TDS Payable	43,190		45,093	
GST Recovery Payable	1,51,915		1,11,317	
GSLI Premium Payable	150		-	
Interest Payable to DAE (NP)	3,66,941		-	
Interest Payable to DAE (Plan)	16,06,339		-	
WCT Recovery Payable	89,013		89,013	
		24,15,764		29,12,306
2. Other Liabilities:				
Earnest money Deposit	22,30,530		21,61,070	
Caution money from Scholars	12,000		10,200	
GSLI Claim Payable	28,223		-	
Pension Payable	-		37,30,438	
Project Grant Payable	50,00,000		-	
Provision for Expenses	3,20,35,013		2,60,92,515	
Provident Fund Payable	-		11,262	
SSB Fellowship Payable	-		15,000	
Deputed Staff Recovery Payable	32,090		-	
Gratuity Payable	2,87,123		-	
Non-Plan Recovery Payable	3,200		-	
Security Deposit - contractors	16,11,804		14,59,294	
		4,12,39,983		3,34,79,779
TOTAL (A)		**4,36,55,747**		**3,63,92,085**

REGISTRAR

DIRECTOR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS (Contd....):				
B. PROVISIONS				
1. Gratuity		7,32,20,096		6,92,58,198
2. Superannuation / Pension		-		-
3. Accumulated Leave Encashment		7,03,19,759		6,66,58,491
4. Others (Specify)		-		-
TOTAL (B)		**14,35,39,855**		**13,59,16,689**
TOTAL (A + B)		**18,71,95,602**		**17,23,08,774**

REGISTRAR
INSTITUTE OF PHYSICS
BHUBANESWAR

DIRECTOR
INSTITUTE OF PHYSICS
BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

(Amount - Rs.)

SCHEDULE 8 - FIXED ASSETS

DESCRIPTION	GROSS BLOCK				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	21,09,86,379	-	-	21,09,86,379	4,68,02,457	1.63	34,39,078	-	5,02,41,535	16,07,44,844	16,41,83,922
3. ROADS	65,48,158	-	-	65,48,158	44,41,923	19.00	12,44,150	-	56,86,073	8,62,085	21,06,235
4. PLANT MACHINERY & EQUIPMENT	80,44,07,949	6,68,42,913	-	87,12,50,862	36,19,87,849	5.28	4,60,02,046	-	40,79,89,895	46,32,60,967	44,24,20,100
5. COMPUTER/PERIPHERALS	14,42,86,185	38,48,785	-	14,81,34,970	11,23,35,660	16.21	2,40,12,679	-	13,63,48,339	1,17,86,631	3,19,50,525
6. Capital Work in Progress	-	-	-	-	-	-	-	-	-	-	-
TOTAL (A)	**1,17,12,28,671**	**7,06,91,698**	**-**	**1,24,19,20,369**	**52,55,67,889**		**7,46,97,953**	**-**	**60,02,65,842**	**64,16,54,527**	**64,56,60,782**
B. FIXED ASSETS (NON-PLAN)											
1. VEHICLES	28,70,817	-	-	28,70,817	19,32,137	9.50	2,72,728	-	22,04,865	6,65,952	9,38,680
2. FURNITURE, FIXTURES	2,31,10,795	2,83,667	-	2,33,94,462	2,12,08,913	9.50	26,948	-	2,12,35,861	21,58,601	19,01,882
3. OFFICE EQUIPMENT	12,87,05,150	6,46,589	-	12,93,51,739	12,26,07,622	9.50	61,426	-	12,26,69,048	66,82,691	60,97,528
4. ELECTRIC INSTALLATIONS	4,88,74,502	20,46,091	-	5,09,20,593	85,16,261	6.33	32,23,274	-	1,17,39,535	3,91,81,058	4,03,58,241
5. LIBRARY BOOKS	44,60,23,977	1,85,47,936	-	46,45,71,913	37,11,64,543	9.50	4,41,34,332	-	41,52,98,875	4,92,73,038	7,48,59,434
TOTAL (B)	**64,95,85,241**	**2,15,24,283**	**-**	**67,11,09,524**	**52,54,29,476**		**4,77,18,708**	**-**	**57,31,48,184**	**9,79,61,340**	**12,41,55,765**
TOTAL OF CURRENT YEAR (A+B)	**1,82,08,13,912**	**9,22,15,981**	**-**	**1,91,30,29,893**	**1,05,09,97,365**		**12,24,16,661**	**-**	**1,17,34,14,026**	**73,96,15,867**	**76,98,16,547**
PREVIOUS YEAR	1,67,82,61,923	14,28,99,095	3,47,106	1,82,08,13,912	93,47,02,350		11,66,42,121	3,47,106	1,05,09,97,365	76,98,16,547	74,35,59,573

PARTHA & MEHRA & CO. Chartered Accountants FRN 324878

रजिस्ट्रार/REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
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भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.				
A. CURRENT ASSETS:				
1. Inventories:				
a) Electrical Fittings Stock	12,60,373		10,82,983	
b) Office Stationery	3,18,811		3,45,949	
c) Computer Stationery	1,56,410		3,65,242	
d) Cleaning Material Stock	-		23,183	
e) Diesel Stock	85,026		81,349	
f) Carpentry Material Stock	27,866		1,35,774	
g) Workshop Spares	4,02,602		6,34,564	
h) PH Material Stock	35,415		59,354	
		22,86,503		27,28,398
2. Cash balances in hand (including cheques/ drafts and imprest)		1,976		29,588
3. Bank Balances:				
a) With Scheduled Banks:				
i) In current accounts SBI		26,96,235		59,58,472
b) Savings accounts				
i) IOB CS Pur (Non-Plan)	1,86,14,872		1,21,60,145	
ii) IOB CS Pur (Plan)	32,01,028		6,52,29,103	
iii) UBI CS Pur (Non-Plan)	62,618		17,40,808	
iv) UBI CS Pur (Plan)	22,229		21,468	
v) Project Bank Account	90,84,957		1,14,84,655	
		3,09,85,704		9,06,36,179
TOTAL (A)		**3,59,70,418**		**9,93,52,637**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2019

(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	1,53,700		1,39,200	
b) Motor Cycle Advance	-		-	
c) Motor Car Advance	2,000		14,000	
d) House Buildings Advance	-		4,000	
		1,55,700		1,57,200
2. Interest Accrued but not due on Loans				
a) Motor Cycle Advance	-		4,097	
b) House Buildings Advance	52,459		67,839	
c) Computer Advance	5,075		8,444	
		57,534		80,380
3. Loans (Non-Interest bearing):				
a) Staff Advance	10,754		1,67,137	
b) Travel Advance	2,32,000		9,31,700	
		2,42,754		10,98,837
4. Advances and other amounts recoverable in cash or in kind or for value to be received:				
a) On Capital Account	-		45,44,913	
b) Prepayments	1,03,497		96,584	
c) Security deposit With CESCO	26,21,944		26,21,944	
d) Franking machine deposit	35,482		45,846	
e) Security Deposit with BSNL	2,000		2,000	
f) Security Deposit for GAS	20,950		20,950	
g) STDR against L/C	2,19,97,993		30,77,093	
		2,47,81,866		1,04,09,330
TOTAL (B)		**2,52,37,854**		**1,17,45,747**
TOTAL (A + B)		**6,12,08,272**		**11,10,98,384**

PARTHA S. MISHRA & CO. Chartered Accountants FRN 328007E

REGISTRAR

DIRECTOR / INSTITUTE OF PHYSICS

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 13 - GRANTS/ SUBSIDIES				
1. DAE - Government of India				
a) Non-Plan (Salary)	21,70,00,000		21,85,00,000	
b) Non-Plan (General)	8,40,00,000		8,11,00,000	
c) Plan	3,00,00,000		9,00,00,000	
		33,10,00,000		38,96,00,000
2. Government Of Orissa (Non-Plan Revenue)		-		-
TOTAL		**33,10,00,000**		**38,96,00,000**

PARTHA S. MISHRA & CO. Chartered Accountants FRN 324007E

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 17 - INTEREST EARNED				
1. On Term Deposits:				
a) With Scheduled Banks	-		-	
b) Others (L/C & Security Deposit)	3,57,238		3,57,238	
		3,57,238		3,57,238
2. On Savings Accounts:				
a) With Scheduled Banks		-		-
3. On Loans:				
a) Computer Advance	7,825		9,800	
b) House Building Advance	60,531		-	
c) Motor Cycle Advance	-		5,894	
d) Pending Advance	13,768		3,481	
		82,124		19,175
TOTAL		**4,39,362**		**3,76,413**

PARTHA P. MISHRA & CO. Chartered Accountants

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 18 - OTHER INCOME				
1. Miscellaneous Income		9,40,850		15,18,631
2. Sale of Tender paper		-		3,500
3. House/Guest House Rent		17,69,455		21,59,708
4. Sale of Assets		-		-
5. CHSS Contribution Recovery		1,80,979		-
5. Profit on Sale of Asset		-		56,101
TOTAL		**28,91,284**		**37,37,940**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 20 - ESTABLISHMENT EXPENSES				
1. Salaries and Wages				
a) Staff Salary	11,26,66,485		12,17,08,057	
b) NPS Contribution	30,88,691		23,00,632	
c) Honorarium	14,83,658		16,37,884	
d) Fellowship	1,76,63,586		1,67,48,381	
e) Temporary Status Employee Salary	-		1,23,055	
f) Remuneration to Medical Officer	4,20,000		4,20,000	
		13,53,22,420		14,29,38,009
2. Allowances and Bonus				
a) PRIS	2,84,70,671		96,07,444	
b) Update Allowance	26,87,552		22,90,928	
c) Overtime Allowance	18,641		31,220	
d) Night Duty Allowance	-		31,849	
		3,11,76,864		1,19,61,441
3. Staff Welfare Expenses				
a) Reimbursement of Medical Expenses	28,41,753		44,67,112	
b) Canteen Expense	-		10,806	
c) Recreation & Welfare Expenses	6,61,282		8,91,010	
d) Children Education Allowance	18,57,350		13,62,759	
e) Medical Aid Centre Expenses	20,159		3,356	
		53,80,544		67,35,043
4. Retirement and Terminal Benefits				
a) Leave salary	1,07,97,523		70,08,732	
b) Pension	3,66,07,848		3,92,74,748	
c) Gratuity	1,17,18,999		43,04,682	
		5,91,24,370		5,05,88,162
5. Others				
a) Contigency Grant to Scholars		11,44,780		15,45,644
TOTAL		**23,21,48,978**		**21,37,68,299**

Chaturbhuja Mishra & Co. Chartered Accountants

रजिस्ट्रार / REGISTRAR

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES ETC.				
1. MAINTENANCE - a) Civil	57,10,500		50,24,152	
b) Vehicle	6,51,978		5,98,435	
c) Library	19,29,855		1,03,043	
d) Workshop	3,84,431		5,61,270	
e) Furniture	74,245		1,70,272	
f) Electrical	5,05,595		17,15,873	
g) AC Plant	42,38,194		36,24,523	
h) Computer	44,38,773		42,32,043	
i) Laboratory	73,90,253		81,65,867	
j) Garden	1,61,613		1,94,831	
k) Telephone	4,84,962		3,26,765	
l) Office Equipment	2,28,559		2,07,571	
		2,61,98,958		2,49,24,645
2. Electricity and power		2,30,61,011		2,23,83,066
3. Water charges		3,03,041		2,90,993
4. Conference & Symposia		12,84,122		6,00,282
5. Science Outreach Activities		7,00,208		6,49,423
6. Postage & Telegram		1,45,878		1,50,136
7. Telephone & Telex		5,70,584		19,56,622
8. Printing and Stationery		9,44,283		8,57,928
9. Travelling Expenses - a) Conference TA	4,66,827		8,77,515	
b) Foreign Travel	5,83,361		5,52,216	
c) Visiting scientist TA	(63,931)		5,79,259	
d) Domestic Travel	16,32,179		16,74,066	
e) Leave Travel concession	9,36,338		7,80,993	
f) Hire Charge	18,954		24,064	
		35,73,728		44,88,113
SUB-TOTAL (A)		**5,67,81,813**		**5,63,01,208**

PARTHA S. MISHRA & CO.
FRN 324187E

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2019

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES Contd....				
10. Auditors Remuneration		59,000		59,000
11. Entertainment Expenses		2,75,547		3,49,392
12. Security Charges		54,34,108		83,90,886
13. Professional Charges		2,24,612		6,93,875
14. Project Revenue Expenses				
a) ALICE Utilisation and CBM Participation	20,00,494		27,44,509	
b) Development of Computing and Network Facilities	13,37,344		22,28,718	
c) Strengthening Low Energy Accelerator	1,50,255		3,78,256	
d) Study of Growth and Characterisation	-		2,941	
e) Investigating Spin Structure	17,475		1,63,525	
f) Vigyan Pratibha	465		-	
g) Infrastructure and Housing	40,90,462		67,07,735	
		75,96,495		1,22,25,684
15. Advertisement and Publicity		16,26,592		5,35,773
16. Others				
a) Miscellaneous Expenses	1,80,767		3,06,017	
b) JEST Expenses	1,63,994		39,319	
c) Interest refund to DAE	-		27,46,130	
		3,44,761		30,91,466
SUB-TOTAL (B)		**1,55,61,115**		**2,53,46,076**
GRAND TOTAL (A + B)		**7,23,42,928**		**8,16,47,284**

PARTHA S. MISHRA & CO. Chartered Accountants FRN 324827E

REGISTRAR / INSTITUTE OF PHYSICS / BHUBANESWAR

DIRECTOR / INSTITUTE OF PHYSICS / BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR
STATEMENT OF RECEIPTS & PAYMENTS FOR THE FINANCIAL YEAR 2018-19

(Figure in Rs.)

	RECEIPTS	SCH	Current Year	Previous Year		PAYMENTS	SCH	Current Year	Previous Year
I.	**Opening Balances**				I.	**Expenses**			
	a) Cash in hand		29,588	31,622		a) Establishment Expenses (Corresponding to Sch 20)	C	22,15,17,919	22,98,45,591
	b) Bank balances					b) Administrative Expenses (Corresponding to Sch 21)	D	6,27,17,441	6,82,76,939
	i) In current accounts SBI		59,58,472	2,14,81,712	II.	**Payments made against funds for various projects**		1,26,03,153	74,38,012
	ii) In Savings accounts				III.	**Investments and deposits made**			
	Indian Overseas Bank (NP)		1,21,60,145	4,54,03,617		a) Out of Earmarked/Endowment funds		-	-
	Indian Overseas Bank (Plan)		6,52,29,103	1,40,98,177		b) Out of Own Funds (Investments-Others)		-	-
	Union Bank (NP)		17,40,808	1,19,274	IV.	**Expenditure on Fixed Assets & Capital W.I.P**			
	Union Bank (Plan)		21,468	47,93,592		a) Purchase of Fixed Assets	E	10,68,64,367	8,77,40,165
	Project Bank Account		1,14,84,655	2,11,196		b) Expenditure on Work-in-Progress		-	-
II.	**Grants Received**				V.	**Refund of surplus money/Loans**			
	a) From Govt. of India - Plan		3,00,00,000	9,00,00,000		a) To the Government of India		-	-
	Non-Plan		30,10,00,000	29,96,00,000		b) To the State Government		-	-
	b) From State Government		-	-		c) To other providers of funds		-	-
III.	**Receipt from Sponsored Project**		1,02,03,455	1,87,11,471	VI.	**Finance Charges (Interest)**		-	-
IV.	**Interest Received**				VII.	**Other Payments**			
	a) On Bank deposits		-	-		Project Revenue Expenses	F	72,02,888	1,36,30,149
	b) Loans, Advances etc.	A	4,62,208	3,90,750		Staff Loan	G	1,30,500	1,46,500
V.	**Other Income**				VIII.	**Closing Balance**			
	Misc Receipts		9,12,890	13,11,260		a) Cash in hand		1,976	29,588
	Sale of Tender paper		-	3,500		b) Bank balances			
	House/Guest House Rent		17,69,455	21,59,708		i) In current accounts SBI		26,96,235	59,58,472
	Sale of Asset		-	56,101		ii) Savings accounts			
VI.	**Amount Borrowed**		-	-		Indian Overseas Bank (NP)		1,86,14,872	1,21,60,145
VII.	**Any Other Receipts**					Indian Overseas Bank (Plan)		32,01,028	6,52,29,103
	Earnest Money Deposit		72,960	12,25,700		Union Bank (NP)		62,618	17,40,808
	Security Deposit		1,75,570	(7,28,165)		Union Bank (Plan)		22,229	21,468
	Caution Money		3,200	1,800		Project Bank Account		90,84,957	1,14,84,655
	Recoveries / Current Dues	B	34,96,206	48,30,280					
	TOTAL		**44,47,20,183**	**50,37,01,595**		**TOTAL**		**44,47,20,183**	**50,37,01,595**

For PARTHA S. MISHRA & CO.
Chartered Accountants

P.S. Mishra (FCA, DISA)
Partner, M. No.-060108

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2019

(Amount Rs)

	Current Year	Previous Year
SCHEDULE A - INTEREST ON LOANS & ADVANCES		
Interest on House Building Advance	75,911	15,959
Interest on Motor Cycle Advance	4,097	1,797
Interest on Computer Advance	11,194	12,275
Interest on Pending Advance	13,768	3,481
Interest on Security Deposit	3,57,238	3,57,238
Total	**4,62,208**	**3,90,750**

PARTHA P. MISHRA & CO. Chartered Accountants FRN 324867E

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2019

(Amount Rs)

	Current Year	Previous Year
SCHEDULE B - RECOVERIES & CURRENT DUES		
Advance For Motor Cycle	-	27,250
Advance For Motor Car	12,000	12,000
Advance For House Building	4,000	12,000
Advance For Computer	1,16,000	51,700
Advance For Festival	-	1,13,400
CHSS Contribution Recovery	1,80,979	-
Deputed Staff Recovery Payable	32,090	-
Gratuity Payable	2,87,123	-
GSLI Premium Payable	150	-
Interest Payable to DAE (NP)	3,66,941	-
Non-Plan Recovery Payable	3,200	-
GSLI Claim Payable	28,223	(36,746)
NPS Recovery Payable	(1,18,436)	93,914
Pension Payable	(53,266)	35,98,640
Professional Tax Payable	(725)	(52,825)
Project Grant Payable	50,00,000	(12,46,000)
GST Recovery Payable	40,598	1,11,317
Plan GST Payable	51,450	-
Plan TDS Payable	(1,903)	45,093
Provident Fund Payable	(11,262)	11,262
TDS Non-Salary Payable	(27,842)	(1,36,076)
TDS Salary Payable	(24,13,114)	24,80,604
WCT Recovery Payable	-	(2,55,253)
Total	**34,96,206**	**48,30,280**

PARTHA S. MISHRA & CO. Chartered Accountants FRN 324867E

REGISTRAR INSTITUTE OF PHYSICS BHUBANESWAR

DIRECTOR INSTITUTE OF PHYSICS

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2019

(Amount Rs)

	Current Year	Previous Year
SCHEDULE C - Establishment Expenses		
Salary	11,24,69,310	12,90,27,085
NPS	30,78,502	20,53,224
PRIS	1,93,84,081	2,46,17,558
Update Allowance	22,66,299	16,07,226
Leave Salary	84,73,433	29,33,678
Temporary Status Salary	-	1,39,230
Book Grant & Contigency	11,44,780	15,45,644
Canteen Expenses	-	10,806
Entertainment	2,75,547	3,47,592
Honorarium	14,21,258	16,52,723
Overtime Allowance	21,495	34,904
Children Education Allowance	14,06,610	1,19,249
Pension	3,98,42,733	3,87,36,210
Pre Doctoral Fellowship	42,60,302	28,19,237
Doctoral Fellowship	92,88,015	94,62,939
Post Doctoral Fellowship	40,79,804	40,89,405
SSB Award Fellowship	-	-
Recreation Club Expenses	6,61,282	8,91,010
Reimbursement of Medicine	27,21,158	42,98,962
Remuneration Medical Officer	4,20,000	4,20,000
Medical Aid Centre Expenses	20,159	3,356
Visiting Scientist TA	(63,931)	5,79,259
Leave Travel Concession	7,82,638	9,10,463
Gtatuity	95,64,444	35,45,831
Total	**22,15,17,919**	**22,98,45,591**

PARITHA S. MISHRA & CO. Chartered Accountants

REGISTRAR / INSTITUTE OF PHYSICS / BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2019

(Amount Rs)

	Current Year	Previous Year
SCHEDULE D - Administrative Expenses		
Administrative		
Advertisement	13,82,759	5,35,773
Audit Fees	59,000	59,000
Conferene & Symposia	12,84,122	6,00,282
Science Outreach activities	6,85,418	7,49,443
Interest Refund to DAE	-	27,46,130
Electricity Charges	2,30,87,124	2,24,16,935
Night Duty Allowance	-	65,960
Miscellaneous Expenses	1,80,767	3,06,017
Postage & Telegraph	1,26,514	1,83,545
Printing Stationey	9,17,145	10,96,363
Security Services	54,20,150	85,57,289
Foreign Travel Expenses	4,75,361	6,18,216
Domestic Travel Expenses	16,32,179	16,74,066
Confernce TA	4,66,827	8,77,515
Telephone & Telex	5,41,561	19,81,775
Water Charges	3,01,774	2,89,785
Hire Charge	18,954	24,064
JEST Expenses	53,994	1,49,319
Professional Charges	2,24,612	6,93,875

PARTHA S. MISHRA & CO. Chartered Accountants

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2019

(Amount Rs)

	Current Year	Previous Year
SCHEDULE D - Administrative Expenses (Contd....)		
Maintenance		
Computer Maintenance	41,43,761	39,08,358
Laboratory Maintenance	70,07,327	85,54,507
Civil Maintenance	57,12,940	47,38,568
Office Equipment Maintenance	2,39,120	2,02,598
Furniture Maintenance	74,245	1,70,272
Library Maintenance	19,05,855	1,03,043
AC Plant Maintenance	41,94,644	35,58,723
Garden Maintenance	1,61,613	1,95,544
Electrical Maintenance	11,24,264	10,88,924
Telephone Maintenance	4,84,962	3,26,765
Workshop Maintenance	1,52,469	11,95,834
Vehicle Maintenance	6,57,980	6,08,451
Total	**6,27,17,441**	**6,82,76,939**

PARTHA S. MISHRA & CO. Chartered Accountants FRN 324467E

REGISTRAR INSTITUTE OF PHYSICS BHUBANESWAR

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2019

(Amount Rs)

	Current Year	Previous Year
SCHEDULE E - PURCHASE OF FIXED ASSETS		
NON-PLAN		
Books	-	14,06,613
Library & Journals	1,85,47,936	3,84,12,617
Office Equipment	6,46,589	25,68,477
Furnitue & Fixtures	2,83,667	12,06,265
Telephone Equipment	-	-
Computer Equipment	31,090	-
Workshop Equipment	11,200	2,43,582
Electrical Installation	20,46,091	90,800
Vehicle	-	5,72,181
Laboratory Equipment	4,23,820	23,78,171
PLAN		
ALICE Utilization and CBM participation	7,37,765	36,97,913
Development of Computing & Network Facilities	30,62,754	69,30,019
Development of Research in HEP	-	-
Strengthening Low Energy Accelerator	4,02,18,880	1,27,56,479
Study of Growth & Characterization of Advanced Materials	3,93,76,268	82,63,885
Theoretical Condensed Matter and Quantum Information	-	15,10,529
Infrastructure & Housing	-	65,95,493
Investigating Spin Structure	14,78,307	11,07,141
Total	**10,68,64,367**	**8,77,40,165**

PARTHA S. MISHRA & CO. Chartered Accountants FRN 334001E

REGISTRAR INSTITUTE OF PHYSICS BHUBANESWAR

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2019

(Amount Rs)

	Current Year	Previous Year
SCHEDULE F - PROJECT REVENUE EXPENSES		
PLAN		
ALICE Utilization and CBM participation Expenses	15,62,494	30,72,509
Development of Computing & Network Facilities Expenses	13,37,344	22,28,718
Strengthening Low Energy Accelerator Expenses	1,50,255	3,78,256
Study of Growth & Characterization of Advanced Materials Expenses	(5,000)	11,33,799
Theoretical Condensed Matter and Quantum Information Expenses	-	(5,000)
Infrastructure Expenses	41,63,202	66,34,995
Vigyana Pratibha Expenses	465	-
Investigating Spin Structure Expenses	(5,872)	1,86,872
Total	**72,02,888**	**1,36,30,149**

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INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF RECEIPTS & PAYMENTS FOR THE YEAR ENDED 31ST MARCH 2019

(Amount Rs)

	Current Year	Previous Year
SCHEDULE G - STAFF LOAN		
Advance For Festival	-	-
Advance For Motor Cycle	-	-
Advance For Computer	1,30,500	1,46,500
Advance For Medical	-	-
Total	**1,30,500**	**1,46,500**

INSTITUTE OF PHYSICS
BHUBANESWAR

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31.03.2019

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. Physical Stock verification has been made for the year 2017-18. One Laptop was found missing during Physical Stock verification, the cost of which has been recovered from the person concerned as per rule.

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 not zero as per the fixed assets schedule for opening balances and current year additions have been charged for the full year.

   5.2. Assets costing Rs.5000/- or less are fully provided.

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6. **GOVERNMENT GRANTS / SUBSIDIES**

The grants are accounted for on realisation basis.

6.1. Plan & Non-Plan grants utilised for capital expenditure is treated as General Fund.

6.2. Plan & Non-Plan grants utilised for revenue expenditure has been taken into Income & Expenditure A/c. as expenditure.

7. **FOREIGN CURRENCY TRANSACTIONS**

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

8. **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.

9. **RETIREMENT BENEFITS**

9.1. Liability in respect of Gratuity on retirement payable as on 31.03.2019 has been provided in accounts on actuarial valuation.

9.2. Provision for liability towards accumulated leave encashment benefit to the employees as on 31.03.2019 has been provided for in accounts on actuarial valuation.

9.3. Provision for liability payable towards Pension to employees has not been provided in the Accounts and is accounted on Cash basis.

9.4. No Pension fund has yet been created by the Institute.

9.5. 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.

9.6. 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 31.03.2019 has been audited by a firm of Chartered Accountants.

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SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31.03.2019

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 31.03.2019 against 100% margin money	2,19,97,993/-
1.5.	Disputed demand in respect of	
	Income Tax (TDS) as on 31.03.2018	NIL
	Sales Tax (IDS)	NIL
	Municipal Taxes	NIL
1.6.	In respect of claims from parties for non-execution of orders	NIL
1.7	Salary & Pensionary benefits accruing to Sri C.B.Mishra, Ex-Registrar against judgement of Orissa High Court in W.P. No. 23137/2014	1,20,00,000/-

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.

PARTHA S. MISHRA & CO. FRN 324687E Chartered Accountants

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All Unclaimed liabilities for more than 3 years have been taken into Miscellaneous Income.

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. 2,19,97,993/- includes the following:

Date of Payment	Head of A/c	Party Name	Item Name	Amount
18/03/2016	Study of Growth & characterisation	Oxford Instrument	Energy dispersive system	7,74,540
14/11/2018	Strengthening Low Energy	Tektronix Asia Ltd	Integrated Resistance measurement	3,70,833
14/11/2018	Strengthening Low Energy	Lakeshore Cryotronic	Low Temperature Probe Station	4,14,970
04/01/2019	Strengthening Low Energy	Twente Solid State	Rheed Assisted Thin Film system	37,37,650
28/02/2019	Strengthening Low Energy	Danfysik AS Denmark	Magnet Power Station	63,00,000
28/02/2019	Strengthening Low Energy	Heidelberg Instrument	Laser based Lithography	1,04,00,000

2.9. Miscellaneous Income includes Unclaimed Liability of Rs.27,960/- towards Caution Money from Scholars (Rs.1,400/-), Security Deposit from Contractors (Rs.23,060/-) & Earnest Money Deposit (Rs.3,500/-).

2.10. 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.

2.11. Schedule 1 to 25 are annexed to and form an integral part of the Balance Sheet as at 31.03.2019 and Income & Expenditure Account for the year ended on that date.

PANTHA S. MISHRA & CO. Chartered Accountants

REGISTRAR INSTITUTE OF PHYSICS

DIRECTOR INSTITUTE OF PHYSICS

2.12. FOREIGN CURRENCY TRANSACTIONS

Value of Imports calculated on C.I.F/Ex-works & FOB basis	31.03.2019 (Rs.)	31.03.2018 (Rs.)
a) Purchase of Lab. Equipments	5,32,74,738	1,45,60,994
b) Stores, Spares and Consumables	43,98,804	38,27,339
c) Journal subscription	1,85,35,020	3,79,99,042
Expenditure in foreign currency		
a) Travel	Nil	Nil
b) Other expenditure (Honorarium)	57,754	Nil
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

P.S. Mishra (FCA, DISA)
Partner, M. No.-050108

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ACTION TAKEN REPORT ON THE COMMENTS OF STATUTORY AUDITORS ON THE ANNUAL ACCOUNTS OF INSTITUTE OF PHYSICS, BHUBANESWAR FOR THE FINANCIAL YEAR 2018-19

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. E- Journals have been capitalized as intangible assets and depreciated for the whole year. E- Journals are paid in calendar yearly basis but the whole years E-journals have been capitalized thus contravening the provisions of the AS10 and AS-6. The depreciation on assets purchased during the year was also charges for the whole year instead of proportionate basis from date to use. The interest from STDR given against Letter of credit should not be deducted from the cost of fixed Assets but should be shown as "Income from Other Sources"	The Institute has engaged M/s.Laldash& Co., CAs vide W.O. No. 793 dt.25.06.2018 for preparation of Asset Register from 2011-12 onwards and they are submitting their report by September 2019. The Institute has been adopting such practice of writing off the Journals. However, the observation of the Audit is noted for future guidance. Interest earned on STDR against L/C have been provided in the Accounts for the year 2018-19 and is due for refund to DAE.
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 Plan and Non-Plan which is treated as Capital Fund as per the provision of Accounting Standard 12.

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<table>
<tr><td colspan="3">Matter of emphasis</td></tr>
<tr><td>1</td><td>The lease deed for 50 acres of land at MouzaNayapalli is not available. However, the copy of the land allotment letter and possession letter ware available in the file. Lease records in respect of 6.130 acres was available. The ROR shows that the 47.32 Acre land belongs to Education Department, Govt. of Odisha. So Institute of physics must take necessary steps to mutate the schedule land in its favor.</td><td>Govt. of Odisha has been requested on the matter and the action is on.</td></tr>
<tr><td>2</td><td>Balances of advances and liabilities recognized from third Parties are subject to confirmation.</td><td>Noted</td></tr>
<tr><td colspan="3">Audit Observation on Accounts</td></tr>
<tr><td>1</td><td>Maintenance of books of accounts:
The following manual books of accounts are maintained in the year 2018-19:
a) Cash cum bank Book
b) Cheque issue register
c) Staff advance register
d) Security deposit register
e) TDS register</td><td>No comment.</td></tr>
<tr><td>2</td><td>Cash and Bank:
a) In some cases the institute has paid cash above Rs. 10000 to visiting scientists/ Employees. Instances are given below:
<table>
<tr><th>Date</th><th>Particulars</th><th>Voucher No</th><th>Amount(Rs.)</th></tr>
<tr><td>29/06/2018</td><td>Honorarium paid to Ashok Das</td><td>CP 25</td><td>70,000</td></tr>
<tr><td>31/07/2018</td><td>Honorarium paid to Ashok Das</td><td>CP 34</td><td>70,000</td></tr>
<tr><td>28/02/2019</td><td>Science Outreach Activities</td><td>CP 94</td><td>2,68,028</td></tr>
</table>
b) The Institute has operated 27 Nos. of Bank accounts. All banks have been reconciled.</td><td>a) The Institute is making almost all payments by NEFT/RTGS. In some remote cases, Cash has been paid to Visiting Scientists who does not have bank account in India. On the occasion of observation of Science Day on 28.02.2019 travel expenses as per actual were paid to about 300 students and their teachers from remote Odisha who participated in it.

b) No Comment.</td></tr>
</table>

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3	**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.	a)

Sl.	Date	Name	Purpose	Amount(Rs.)
1	29/05/2018	M. M. Mondal	Alice	1,12,000.00
2	22/01/2019	Dr. Shikha Varma	Foreign Travel	1,20,000.00
3	30/03/2019	Dr. Dinesh Topwal	Laboratory	10,714.40

a)
1) Travel bill has been submitted by Sri Mondal and has been settled in 2019-20.
2) Travel bill has been settled in 2019-20.
3) Outstanding advance has been settled in 2019-20

b) The STDR aginst L/C are pending as on 31.03.2019 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	Oxford instruments Nano Analysis, UK	29.09.2015	7,74,540
2	Testronix Asia Ltd, USA	27.04.2018	3,70,833
3	Twente Solid State Technology,The Netherlands	02.05.2018	37,37,650
4	LakeShoreCryotronicsinc, USA	30.04.2018	4,14,970
5	DanfysikAS, Denmark	07.03.2019	63,00,000
6	Heidelberg instruments Mikrotechnik, Germany	07.03.2019	1,04,00,000

b) The L/C are opened and settled as per term of the Purchase Order. During the year 2019-20, these outstanding L/C are being settled.

c) During the course of audit, it is noted that a sum of Rs.4,07,776 is due as on 31st March 2019. Details are as given below:

Sl No	Date	Ledger Name	Amount(Rs.)
1	30/03/2019	GST Payable (Plan)	51,450
2	28/02/2019	Gratuity Payable	2,87,123
3	30/03/2019	TDS Payable (Plan)	43,190
4		NPS Payable	26,013
		TOTAL:	**4,07,776**

c)
1) Paid on 08.04.2019.
2) 10% of gratuity payable to retired employees are settled after vacating the quarter allotted to them.
3) Paid on 03.04.2019.
4) Could not be deposited due to non-submission of PRAN by the employees who have already left the Institute

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	d) Fixed Asset Register: - During the course of audit, it is observed that IAS-10 and AS 6 regarding to fixed assets and deprecation respectively, have not been complied with. Further, since fixed asset register was not being maintained by the institute, we are unable to comment over the physical location and working condition of the asset. Further, depreciation is being charged on gross block even in cases where the assets has been fully depreciated.	d) As complied at Sl no 1 of the Action Taken Report (ATR).
	E journal expenses are being written off in the year when the same was subscribed to. However the same should be bifurcated on a proportionately based on the number of months for which the subscription was active in the financial year.	As complied at Sl no 1 of the ATR.
	e) Leasehold Property: - The lease deed for 50 acres of Land at MouizaNayapalli is not available for verification; however the Land allotment and possession letter was available for verification. As per lease record the area was 6.130acre, however as per ROR shows that 47.32 acres land belong to Education Department, Govt of Odisha. So Institute of Physics must take necessary actions to mutate the scheduled land in its favour.	e) As complied at Sl no 1 of the ATR.

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