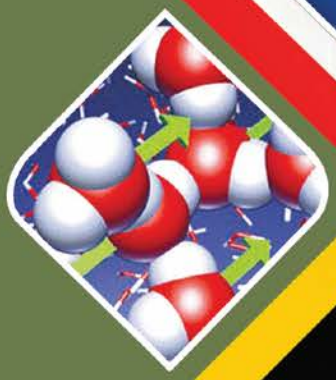
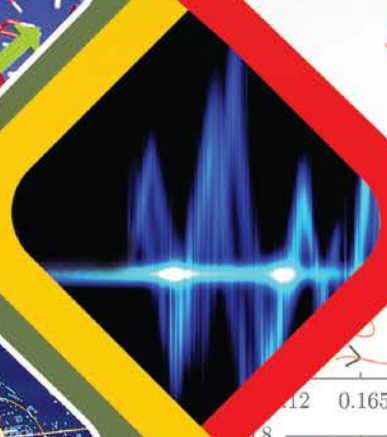
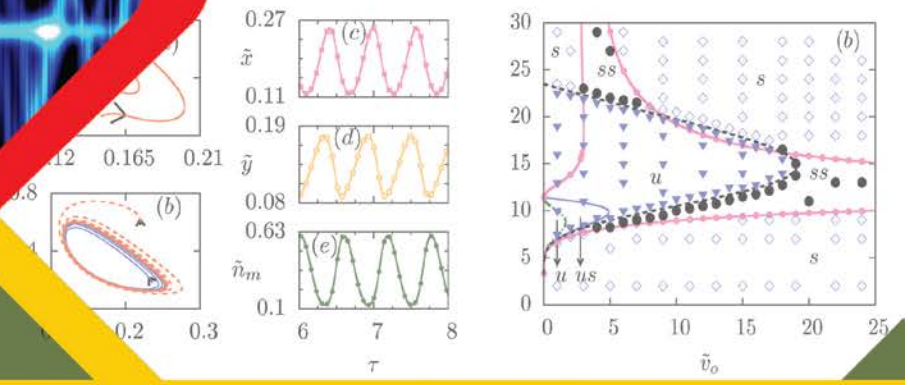
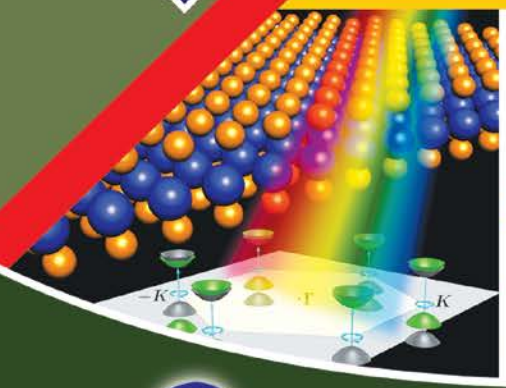
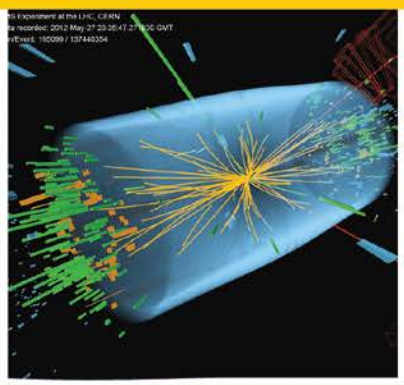
Annual Report
and
Audited Statement of Accounts
2016-17

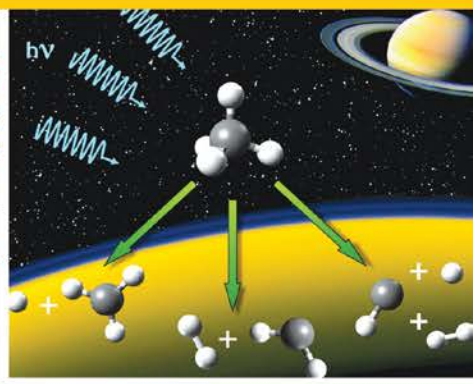












Institute of Physics
Bhubaneswar


भौतिकी संस्थान
INSTITUTE OF PHYSICS
हिंदी पखवाड़ा समारोह

Annual Report

and

Audited Statement of Accounts

2016-17

Institute of Physics

Bhubaneswar

INSTITUTE OF PHYSICS

P.O. Sainik School

Bhubaneswar - 751 005

Odisha, India

Phone: +91-674- 2306 400/444/555

Fax: +91-674- 2300142

URL: http://www.iopb.res.in

Editor

Prof. T. Som

Prof. A. Saha

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Shri Rajesh Mohapatra

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Contents

About the Institute

Institute of Physics, Bhubaneswar is an autonomous research institution of 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, sports and gym facilities are also available in the campus. The Institute also has a guest house, auditorium, open-gym and dispensary in the campus.

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

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Mumbai-400001

The Principal Secretary to Govt. of Odisha,
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Berhampur University, Bhanja Bihar,
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Registrar,
Institute of Physics,
Bhubaneswar -751005, Odisha

From Director's Desk

I am delighted to bring together the activities and accomplishments of Institute of Physics for the year 2016-2017 in this annual report. Institute of Physics (IoP), Bhubaneswar is a premier research institution in India. Since its inception, IoP continues to engage in fundamental & applied research in physics at the frontier areas of international importance.

IoP conducted a series of academic programmes and scientific events during the year 2016-17. In particular, meetings/workshops focusing on condensed matter and materials physics, a thematic school on string theory and many seminars by distinguished speakers were organized at IoP. A number of outreach programmes on atomic energy and nuclear power in the service of mankind were organized through popular lectures and experimental demonstrations by the experts at various remote locations in Odisha to awaken the scientific temperament and bring awareness in the minds of young school/college students. As a part of 2017-National Science day celebration, a series of scientific activities and demonstrations were carried out at IoP. Nearly 300 young students from about thirty educational centers in and around Bhubaneswar actively took part in this celebration. Shri S.C. Jamir, Hon'ble Governor of Odisha graced the event as chief guest. Eastern Regional Chapter for Indian Association of Nuclear Chemists & Allied Sciences (IANCAS) was established at IoP and Director, IoP is the incumbent president for the same.While it is true that IoP is a center for basic and applied science, it makes regular conscious efforts to integrate science into the larger fabric of human activity and life by organizing seminars on arts, humanities, sociocultural issues and ethical values.

It is gratifying to note that the faculty/scientific members of IoP have performed remarkably well in their research which has culminated in more than hundred research publications in the International Peer Reviewed Journals. Besides, the faculty members of IoP have received academic accolades and recognitions like fellowship of Indian Academy of Sciences, NASI Scopus Young Scientist Award, MRSI Medal in Materials Science and Vice President of Electron Microscope Society of India. In the spirit of carrying out novel research on designer quantum materials and emergent phenomena, a Max Planck Partner group with the Max Planck Institute of Solid State Research has been established at IoP. To widen the academic and scientific activities at IOP, three

young and dynamic faculty members working on forefront research areas in high energy physics were hired during the year 2016-17. Eminent Scientists of national and international repute were invited on a short term and regular basis to work in collaboration and exchange ideas with the faculty members and research scholars at IoP. DAE-C.V. Raman lecture organised by Indian Physics Association was held at IoP and Prof. Ashok Das from University of Rochester delivered the lecture.

IoP is seriously looking forward to expand and strengthen its research and academic horizon while the research in various branches of physics is undergoing an exciting phase and transformation worldwide. The real strength of a research institute lies with its faculty members, scientists and research scholars. IoP is contemplating to hire new faculty members with expertise on various emerging and interdisciplinary fields of research that are expected to flourish in the coming years. At the same time, we are also considering the possibility to increase the intake capacity of Ph.D scholars, create the state of the art experimental facilities and to build the required infrastructure.

We realize that we have challenging times ahead with far greater responsibility of conducting cutting edge research in physics and materials science and therefore we need to engage ourselves with renewed intensity and vigor. To foster scientific growth in traditional and new disciplines of research, IoP is committed to attract, nurture and equip young talents to face the challenges of a new India. IoP keeps its doors wide open to work jointly with like-minded individuals and institutions around the world. I am convinced that in days to come, the youthful exuberance and dynamism of our faculty members will take the institute into new heights. On this path towards excellence, new challenges will appear. With the sheer passion for physics and perseverance of our faculty and staff members, together we shall overcome all that comes in our path and carry-out top notch research.

Let us all look forward to more productive years in terms of scientific successes and breakthroughs ahead for IoP.

I sincerely thank all the members associated with IoP including Governing Council for their involvement, encouragement and constant support in making IoP what it is Today. Last but not least, I express my gratitude to those who have worked tirelessly to give a shape to this Annual Report in the present form.

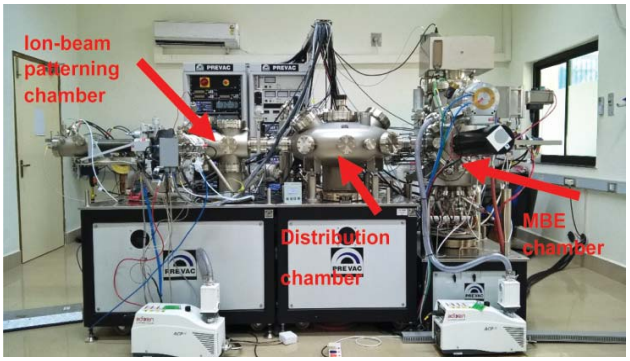
Prof. Sudhakar Panda
Director, IoP

FACILITIES

1.1 MAJOR EXPERIMENTAL FACILITIES

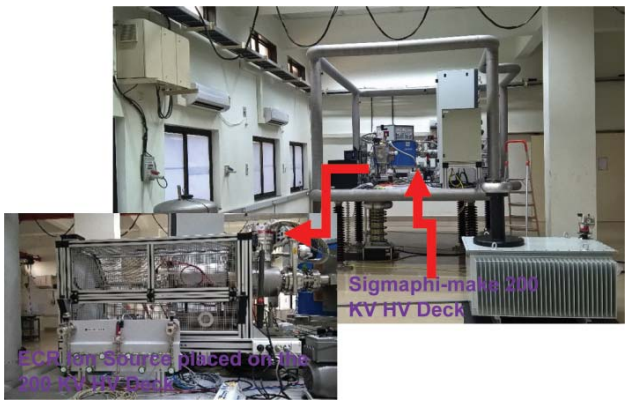
Integrated Low Energy Ion Patterning and UNV Growth System

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

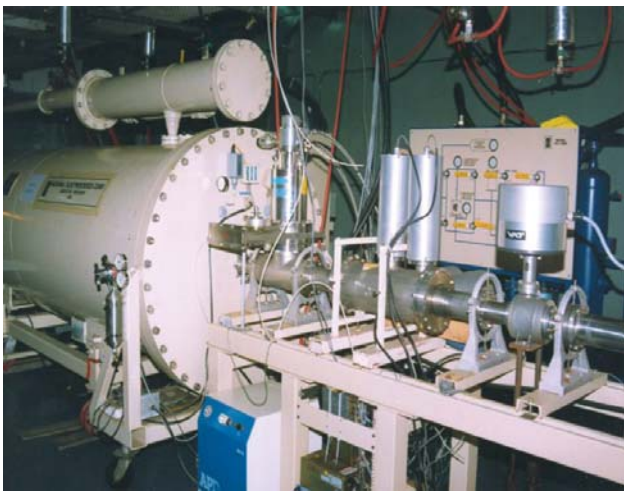


We installed electron cyclotron resonance (ECR) ion source on a 200 KV high voltage deck. This will enable us to accelerate ions to hundreds of keV to a few MeV energy for ion implantation, nanoscale patterning, ion-beam induced epitaxial crystallization, ion-beam mixing, ion-beam shaping, synthesis 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

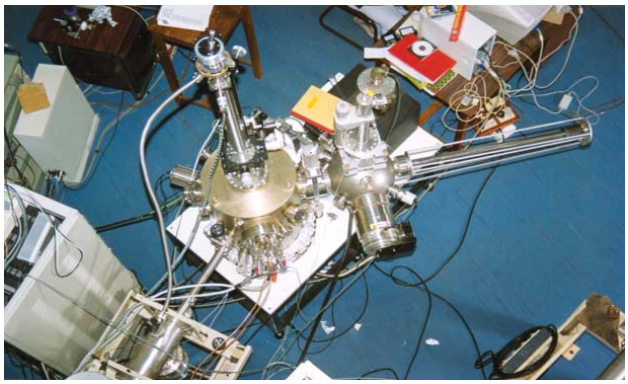
heavy ions (carbon or above) is 3+ for terminal potentials above 2 MV.

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 :

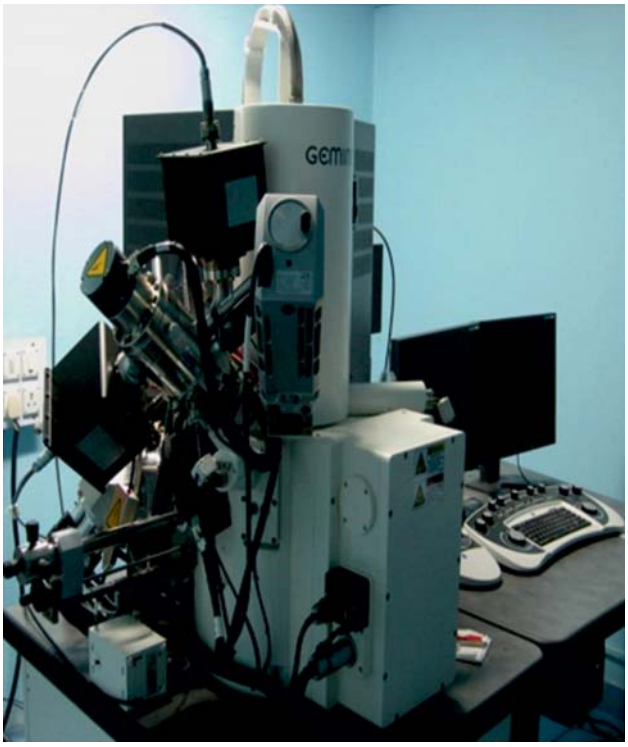
The High Resolution Transmission Electron Microscope (HRTEM) facility consists of two components: Jeol 2010 (UHR) TEM and Associated Specimen Preparation system. High-Resolution Transmission Electron Microscopy

(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

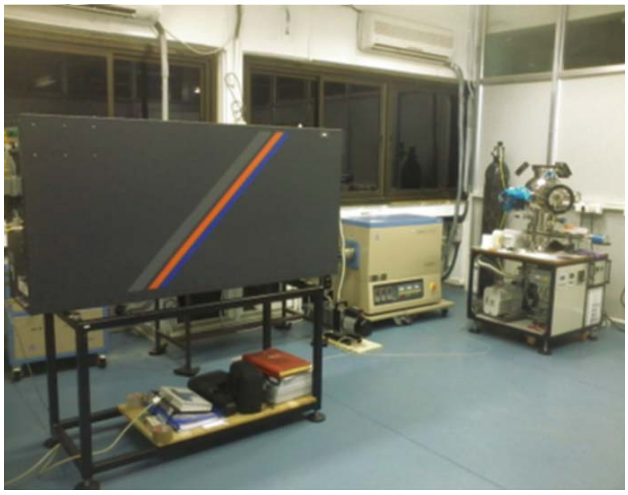
The Angle Resolved Ultraviolet Photoelectron Spectrometer (ARUPS) is equipped with facilities for doing both angle integrated valence band measurements as well as angle

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

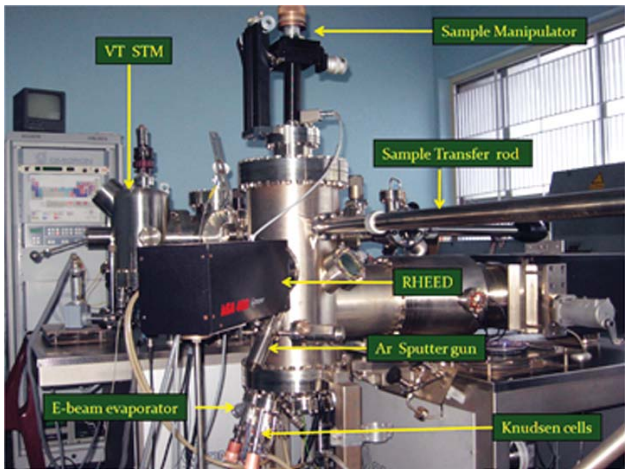
We have installed a pulsed DC/RF magnetron based sputter deposition unit. The unit has four sputter guns where two are

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.

1.2 COMPUTER FACILITY

The computer facility of the Institute can be broadly divided into different catagories for scientific computation, Local Area Network (LAN), access to internet and automation of library and administration. There are about two hundred PC's installed in the computer center, laboratories and offices of faculties, scholars and administration in the Institute. About 10 servers, the central network hub, firewall, about twenty PC's and network printers are installed in the computer center. User's data and general utilities are centrally stored in the file server and are made available on the user's desktop PC's by NFS over LAN. Programs which require large amount of computation are run in HPC's. Procurement of a thousand node HPC for the Institute is under process.

Number of software packages such as Mathematica, Maple, Origin, IDL, Numerical Recipes are available for carrying out numerical computations, symbolic calculations, graphical analysis, modelling and simulation. GUPIX and SIMNRA software's are available for analysis of experimental data. For preparing scientific documents Latex is available in the PC's running under Linux. Number of printers are installed at different locations of academic building for general printing over LAN.

In the Institute, the gigabit capacity LAN is implemented with three levels of CISCO switches. Two core switches are configured in the redundant mode to load-balance the network traffic. Wireless access points have been set up in the library, computer center, main building, auditorium, lecture hall, guest house and hostel. Access to LAN has been provided to the quarters of faculty and some employees of Institute in the campus through ADSL system using telephone lines. Efforts are being made to extend LAN to the Efficiency Apartment and all quarters in the campus. The LAN is made secure by installation of firewall. Antispam software is installed to filter unwanted mails. Antivirus software has been installed in the PC's running under MS Windows operating system in the offices and laboratories.

The internet link to Institute is available at two dedicated bandwidths of 128mbps each provided by commercial internet service providers and at 100mbps by National Knowledge Network. 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. A seismic monitoring equipment has been installed in the Institute and seismic data is being continuously transmitted to Bhaba Atomic Research Centre for analysis using ANUNET.

The administrative work, such as accounting, personnel management, stores management have been computerized. Several software packages such as MSOffice, Wings 200 Net, Tally and multilingual software are in use.

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

1.3 LIBRARY

The Library facility is available to the members of the Institute as well as members from other academic institutions. The Library holdings include 16,204 books and 23,643 bound Journals, taking the total collection to 39,304. Throughout the year the Library added 544 books to its collection. The Library subscribed 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 containing all articles published up to 2017. During 2016-17 Library also procured 2000+ e-books on Physics and Astronomy of Springer Nature, 131 number of e-books of Cambridge University Press (CUP) and 189 number of e-books of Oxford University Press (OUP), which can be accessible from Library Portal @ http://www.iopb.res.in/~library/ebooks.php. Library also subscribed 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. In order to spread the awareness among the Scientists and Research Community of IOP for the smooth functioning and proper utilization of all e-resourcestraining-cum-demo sessions also arranged.

Besides this, Library is a part of the Department of Atomic Energy Consortium with Elsevier Science, getting access to 2000+ journals with access from 1995 onwards electronically. The Library assists users in obtaining articles from other Libraries in the country under resource sharing programme. The Library also sends out articles as Digital Inter Library Loan (*dill@iopb.res.in*) on request for academic purposes.The Library is fully automated with Libsys4 software on Linux platform which is a fully integrated multi user package with powerful search and query facilities. It supports activities like Acquisition, Cataloguing, Circulation, Serial Control etc. Searching of books and Journals can also be performed using the WEB-OPAC in Library website (http://10.0.1.72:8080/jopacv11/html/SearchForm).

The Library is housed in a centrally air

conditioned building which is open round the clock for convenience of the users. The books and journals circulation system has become very effective with implementation of bar-codes, online reservation and reminders through e-mail to its individual members. Library also provides reprographic services and handles the publication, printing and advertisement division of Institute.

1.4 AUDITORIUM :

We have an auditorium in our campus where we organize Colloquiums, Seminars, Workshops, Conferences, Cultural activities, Social programs regularly. This auditorium can easily accomodate 330 people. It has all the high-quality amenities to organize above mentioned events.

ACADEMIC PROGRAMMES

2.1 PRE-DOCTORAL PROGRAM

One of the most important objectives of the Institute is to train and guide young scholars to do research in physics. Since 1975, IOP has a regular Pre-doctoral (Post M.Sc.) course, which is a very important academic program because it is designed to train the M.Sc. students for carrying out research activities. This programme is aimed at imparting a broad based training in advanced physics and research methodology to students. The course work is planned with the view that it should help a student not only in doctoral research, but also enable him/her to become a good physics teacher irrespective of whether or not he/she takes up doctoral research. Few years back, the Institute joined the Joint Entrance Screening Test (JEST) for students who are interested in taking research 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, 2015 and ended in July, 2016. Utkal, Berhampur and Sambalpur Universities have recognized our Pre-doctoral program equivalent to their M.Phil degrees. On completion of the Pre-doctoral program, students are eligible to join research under the supervision of faculty members of the Institute, leading to the Ph.D. degree awarded by HomiBhabha National Institute (HBNI).

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

A total of 273 students were called for written test and interview for admission to the predoctoral course in July, 2016. This includes JEST qualifiers, UGC-CSIR qualifiers and valid GATE score holders. Following students successfully completed the doctoral course work in July, 2017:

1. Mr. Abhisek Bag
2. Mr. Avnish Yadav
3. Mr. DebjyotiMajumdar
4. Mr. Sayan Jana
5. Mr. Subhadip Jana
6. Mr. Vinay Krishnan M. B.
7. Mr. SudarshanSaha

Mr. Sayan Jana was adjudged the most outstanding scholar and was awarded the L. K. Panda Memorial Fellowship for the year 2016-17.

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

Trimester – I (August - November)

Quantum Mechanics : Prof. S. M. Bhattacharjee

Mathematical Methods : Prof. G. Tripathy

Classical Electrodynamics: Prof. S. Mandal

Theory of Experiments : Prof. T. Som

Laboratory Experiments : Prof. S. Sahoo

Trimester – II (December - March)

Statistical Mechanics : Prof. A. M. Srivastava

Adv. Quantum Mech. : Prof. S. Banerjee &
Prof. D. Samal

Quantum Field Theory : Prof. S. Mukherji

Numerical Methods : Prof. A. Nayak

Advanced Experiments : All Condensed Matter
Experimental faculty members

Trimester – III (April - July)

Cond. Matter Physics – I : Prof. A. Saha

Cond. Matter Physics – II : Prof. D. Choudhuri

Particle Physics : Prof. A. Virmani

Nuclear Physics : Prof. S. K. Patra&
Prof. P. K. Sahu

As a part of the course work, students also worked on projects in the last trimester under supervision of faculty members of the institute. Titles of the projects undertaken by student during 2016-2017 are given below along with the name of the supervisor.

Name of Supervisor	Name of Student	Title of Project
Prof. S. Mandal	**Abhisek Bag**	*Study of time dependent Hamiltonian and Floquet theory*
Prof. K. Ghosh	**Avnish Yadav**	Cosmic signal detection using GEM detector
Prof. D. Choudhuri	**Debjyoti Majumdar**	*Phase ordering in interacting active Brownian particles*
Prof. A. Saha	**Sayan Jana**	*Majorana Fermion in Topological insulator Nanowires*
Prof. D. Samal	**Subhadip Jana**	*Atomic-Layer engineering and dimensionally control of novel electronic phases*
Prof. S. Banerjee	**Vinay Krishnan M. B.**	*Quantum Entanglement and Quantum gravity via AdS-CFT correspondence*
Prof. S. Banerjee	**Sudarshan Saha**	*Introduction to AdS-CFT correspondence*

2.2 DOCTORAL PROGRAM

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

2.3 THESES (Defended / Submitted)

The following scholars have been awarded Ph.D. degree by HomiBhabha National Institute on the basis of thesis submitted.

1. **Mohit Kumar :**

   Advisor : Prof. T. Som

   Thesis Title : *Growth and Characterization of Cu-O Based Solar Cell*,

2. **SkSazim** :

   Advisor : Prof. P. Agrawal

   Thesis Title : *Quantum Correlations in Multiparticle Systems and Its Applications.*

3. **Shalik Ram Joshi** :

   Advisor : Prof. S. Varma

   Thesis Title : *Nanostructure Formation on Rutile TiO2 and Ta Surfaces by Ion Beam Irradiation: Photoabsorption, Magnetism, Scaling and KMC Studies.*

4. **AnjanBhukta** :

Advisor : Prof. P. V. Satyam

Thesis Title :*Au-Ag Bimetallic Nanostructures Growth and Characterization on Ultra Clean Silicon Substrates.*

5. **Ram Chandra Baral** :

Advisor : Prof. P. K. Sahu

Thesis Title : Study of l*(1520) Resonances & D Mesons at the LHC Energies and Phase Transition in Magnetized Compact Stars.*

6. **Subrata K. Biswal** :

Advisor : Prof. S. K. Patra

Thesis Title :*Structural Properties of Finite and Infinite Nuclear Systems and Related Phenomena.*

7. **HimanshuLohani** :

Advisor : Prof. B. R. Sekhar

Thesis Title :*Electronic Structure Studies of Some Topological Insulators and New Superconductors Using Photoelectron Spectroscopy and First Principles Calculations.*

8. **Indrani Mishra** :

Advisor : Prof. S. Varma

Thesis Title :*Modifications of SiOx, TiO2 and PDMS surfaces & their Interactions with DNA and Cell.*

2.4 Summer Students' Visiting Program (SSVP) :

The motivation of the SSVP program is to expose young students to frontline research areas, especially in the areas of research work going on at the Institute. This year the SSVP was held from 25th May to 24th July, 2016. Ten students participated in the program. Round trip train fare, accommodation on campus, and a monthly stipend of Rs. 5000/- 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.

Seminar Delivered by Summer Students

Name of the Student	Topic of the Seminar	Advisor
Bhavini Chaudhari	*Understanding GAMMA ray and X-Ray Detectors*	Prof. P. V. Satyam
Alok Mishra	*Magnetotransport Phenomena in Solids*	Prof. D. Samal
Subhasmita Ray	*Brownian Motion, Viscosity &Visco-elasticity*	Prof. G. Tripathy
Gadiparthi A. Rao	*Electron Microscopy Analysis of Gold Faceted ZnONano wires*	Prof. P. V. Satyam
Smaranika Ray	*Investigation of Microstructural and Optical Properties of Zinc Oxide Nanorods*	Prof. S. Sahoo
Debasmita Swain	*Optical Studies of Silicon Naonwires*	Prof. S. Sahoo
S. Ahmad Shiekh	*Blonder-Tinkham-Klapwijk Modelling of the Normal-Super-Conductor Hybrid Junctions*	Prof. A. Saha
Amit Raj Nayak	*Electrons in a Magnetic Field; Landau Quantization*	Prof. D. Samal

RESEARCH

3.1 Theoretical Condensed Matter Physics

The branch of physics that deals with the physical properties of condensed phases of matter, where particles adhere to each other. In particular, the scientist includes to understand the laws of quantum mechanics, electromagnetism and statistical mechanics in condensed matter systems.

The most familiar condensed phases are solids and liquids while more exotic condensed phases include the superconducting phase exhibited by certain materials at low temperature, the ferromagnetic and antiferromagnetic phases of spins on crystal lattices of atoms, and the Bose–Einstein condensate found in ultracold atomic systems. The study of condensed matter physics involves measuring various material properties via experimental probes along with using methods of theoretical physics to develop mathematical models that help in understanding physical behavior.

The diversity of systems and phenomena available for study makes condensed matter physics the most active field of contemporary physics. Division of Condensed Matter Physics is the largest division of the present research activities. The field overlaps with chemistry, materials science, nanotechnology and related closely to atomic physics and biophysics. Theoretical physics of condensed matter shares important concepts and methods with that of particle physics and nuclear physics.

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

Efimovlike behavior in low-dimensional polymer models

In the quantum Efimov efiect, identical bosons form infinitely many bound trimer states at the bound dimer dissociation threshold, with their energy spectrum obeying a universal geometrical scaling law. Inspired by the formal correspondence between the possible trajectories of a quantum particle and the possible conformations of a polymer chain, the existence of a triple-stranded DNA bound state when a double- stranded DNA is not stable was recently predicted by modelling three directed polymer chains in low-dimensional lattices, both fractal (d < 1) and euclidean (d = 1). A finite melting temperature for double-stranded DNA requires in d ≤ 2, the introduction of a weighting factor penalizing the formation of denaturation bubbles, that is non-base paired portions of DNA. The details of how bubble weighting is defined for a three- chain system were shown to crucially afiect the presence of Efimov-like behaviour on a fractal lattice. Here we assess the same dependence on the euclidean 1 + 1 lattice, by setting up the transfer matrix method for three infinitely long chains confined in a finite size geometry. This allows us to discriminate unambiguously between the absence of Efimov-like behaviour and its presence in a very narrow temperature range, in close correspondence with what was already found on the fractal lattice. When present, however, no evidence is found for triple-stranded bound states other than the ground state at the two-chain melting temperature.

F. Mura, S. M. Bhattacharjee, J. Maji, M. Masetto, Flavio Seno , A. Trovato

Bubble-bound state of triplestranded DNA: Efimov Physics in DNA with repulsion

The presence of a thermodynamic phase of a three-stranded DNA, namely, a mixed phase of bubbles of two bound strands and a single one, is established for large dimensions (d e" 5) by using exact real space renormalization group (RG) transformations and exact computations of specific heat for finite length chains. Similar exact computations for the fractal Sierpinski gasket of dimension d < 2 establish the stability of the phase in presence of repulsive three chain interaction. In contrast to the Efimov DNA, where three strands are bound though no two are bound, the mixed phase appears on the bound side of the two chain melting temperature. Both the Efimov-DNA and the mixed phase are formed due to strand exchange mechanism.

Jaya Maji, F. Seno, A. Trovato and S. M. Bhattacharjee

A multipurpose information engine that can go beyond the Carnot limit

Motivated by the recent work by Mandal and Jarzynski on autonomous Maxwell demon information engine, we have extended their model by introducing two different heat baths. The system (demon) is coupled to a memory register (tape) and a work source. The performance of the system depends on the interplay between these two sources along with the heat baths.

We have found the system can act as an engine, refrigerator or an eraser. Even the combination of any two is possible in some parameter space. We have achieved the efficiency of the engine is greater than Carnot limit. The coefficient of performance of refrigerator also achieves larger than Carnot limit.

Shubhashis Rana and A. M. Jayannavar

Stoke's efficiency and its stochastic properties

We study the Stoke's efficiency and its fluctuating properties in the case of a spatial

asymmetric ratchet potential with a temporal asymmetric driving force from adiabatic to nonadiabatic regime. Our numerical investigations show that the average Stoke's efficiency and the average current decrease with the frequency of driving. For low frequency of driving, i.e., in the case of an adiabatic regime, we reproduced the analytical results supporting our numerical simulations. By evaluating the probability distribution, $p(\varsigma s)$ for Stoke's efficiency, ςs we focus on the stochastic properties of Stokes efficiency. We find that in most of the parameter space, fluctuations in ςs are comparable to or larger than the mean values. In such a situation one has to study the full probability distribution of ςs. With increase in frequency of driving, the distribution becomes multipeaked. At the same time the average Stoke's efficiency decreases with increase in frequency of drive. For high frequency of driving, the distribution develops a peak across zero. Further increase in frequency this peak gets sharper. And finally at sufficiently high frequency we get a strong peak across zero indicating that there is no effective transport in this regime.

M. Sahoo and A. M. Jayannavar

Aharonov-Bohm effect in a helical ring with long-range hopping : Effects of Rashba spin-orbit interaction and disorder

We study Aharonov-Bohm effect in a two-terminal helical ring with long-range hopping in presence of Rashba spin-orbit interaction. We explore how the spin polarization behavior changes depending on the applied magnetic flux and the incoming electron energy. The most interesting feature that we articulate in this system is that zero-energy crossings appear in the energy spectra at $\Phi=0$ and also at integer multiples of half-flux quantum values ($n\Phi 0/2$, n being an integer) of the applied magnetic flux. We investigate the transport properties of the ring using Green's function formalism and find that the zero energy transmission peaks corresponding to those zero energy crossings vanish in presence of Rashba spin-orbit interaction. We also incorporate static random disorder in our system and show that the zero energy crossings and transmission peaks are not immune to disorder even in absence of Rashba spin-orbit interaction. The latter prevents the possibility of behaving these helical states in the ring like topological insulator edge states.

Paramita Dutta, Arijit Saha and A. M. Jayannavar

Transient exchange fluctuation theorems for heat using Hamiltonian framework: Classical and Quantum

We investigate the statistics of heat exchange between a finite system coupled to reservoir(s). We have obtained analytical results for heat fluctuation theorem in the transient regime considering the Hamiltonian dynamics of the composite system consisting of the system of interest and the heat bath(s). The system of interest is driven by an external protocol. We first derive it in the context of a single heat bath. The result is in exact agreement with known result. We then generalize the treatment to two heat baths. We further extend the study to quantum systems and show that relations similar to the classical case hold in the quantum regime. For our study we invoke von Neumann two point projective measurement in quantum mechanics in the transient regime.Our result is a generalisation of Jarzynski-W*o*'jcik heat fluctuation theorem.

P. S. Pal, Sourabh Lahiri and A. M. Jayannavar

Universal fluctuations in orbital diamagnetism: A surprise in theoretical physics

Over the last century Bohr van Leuween theorem attracted the notice of physicists. The theorem states about the absence of magnetization in classical systems in thermal equilibrium. In this paper, we discuss about fluctuations of magnetic moment in classical systems. In recent years this topic has been investigated intensively and it is not free from controversy. We a have considered a system consisting of a single particle moving in a plane. A magnetic field is applied perpendicular to the plane. The system is in contact with a thermal bath. We have considered three cases: (a) particle moving in a homogeneous medium, (b) particle moving in a medium with space dependent friction and (c) particle moving in a medium with space dependent temperature. For all the three cases average magnetic moment and fluctuations in magnetic moment has been calculated. Average magnetic moment saturates to a finite value in case of free particle but goes to zero when the particle is confined by a 2-D harmonic potential. Fluctuations in magnetic moment shows universal features in the presence of arbitrary friction inhomogeneity. For this case the system reaches equilibrium asymptotically. In case of space dependent temperature profile, the stationary distribution is non-Gibbsian and fluctuations deviate from universal value for the bounded system only.

P. S. Pal, Arnab Saha and A. M. Jayannavar

Extracting Work from a single heat bath using velocity dependent feedback

Thermodynamics of nanoscale devices is an active area of research. Despite their noisy surround- ing they often produce mechanical work (e.g. micro-heat engines) or display rectified Brownian motion (e.g. molecular motors). This invokes the research in terms of experimentally quantifiable thermodynamic efficiencies. To enhance the efficiency of such devices, close-loop control is an useful technique. Here a single Brownian particle is driven by a harmonic confinement with time-periodic contraction and expansion, together with a velocity feedback that acts on the particle only when the trap contracts. Due to this feedback we are able to extract thermodynamic work out of the system having single heat bath without violating the Second Law of Thermodynamics. We analyse the system using stochastic thermodynamics.

Arnab Saha, Rahul Marathe and A. M. Jayannavar

Study of Brownian functionals in physically motivated model with purely time dependent drift and diffusion

In this paper, we investigate a Brownian motion (BM) with purely time dependent drift and difusion by suggesting and examining several Brownian functionals which characterize the lifetime and reactivity of such stochastic processes. We introduce several probability distribution functions (PDFs) associated with such time dependent BMs. For instance, for a BM with initial starting point $x0$, we derive analytical expressions for : (i) the PDF $P(tf \mid x0)$ of the first passage time tf which specify the lifetime of such stochastic process, (ii) the PDF $P(A \mid x0)$ of the area A till the first passage time and it provides us numerous valuable information about the effective reactivity of the process, (iii) the PDF $P(M)$ associated with the maximum size M of the BM process before the first passage time, and (iv)the joint PDF $P(M;tm)$ of the maximum size M and its occurrence time tm before the first

passage time. These distributions are examined for the power law time time dependent drift and diffusion. A simple illustrative example for the stochastic model of water resources availability in snowmelt dominated regions with power law time dependent drift and diffusion is demonstrated in details. We motivate our study with approximate calculation of an unsolved problem of Brownian functionals including inertia.

Ashutosh Dubey, Malay Bandyopadhyay and A. M. Jayannavar

Two coupled, driven Ising spin systems working as an Engine

Miniaturized heat engines constitutes a fascinating field of current research. They are being studied theoretically as well as experimentally, with experiments involving colloidal particles and harmonic traps and even bacterial baths acting like thermal baths. They are interesting to study because usual equilibrium thermodynamic notions can not be applied directly to these systems. These systems are micron sized or even smaller and they are subjected to laud thermal fluctuations. Thus one needs to study the behavior of such systems in terms of these fluctuations. Average thermodynamic quantities like work done, heat exchanged, efficiency loose meaning unless otherwise supported by their full probability distributions. Earlier studies on micro-engines are concerned with applying Carnot or Stirling engine protocols to miniaturized systems, where system undergoes typical two isothermal and two adiabatic changes. Unlike these models we for the first time, study a prototype system of two classical Ising spins driven by time dependent, phase different, external magnetic fields. These spins are *simultaneously* in contact with two heat reservoirs at different temperatures for the full duration of the driving protocol. Performance of the model as an engine or a refrigerator depends only on a single parameter namely the phase between two external drivings. We study this system in terms of fluctuations in efficiency and coefficient of performance (COP). We also find full distributions of these quantities numerically and also study the tails of these distributions. We also study reliability of this engine. We find the fluctuations dominate mean values of efficiency and COP and their probability distributions are broad with power law tails.

Debarshi Basu, Joydip Nandi, A. M. Jayannavar and Rahul Marathe

Thermoelectric properties of a ferromagnet-superconductor hybrid junction: Role of interfacial Rashba spin-orbit interaction

We explore thermal transport phenomena through a ferromagnet-superconductor hybrid structure with Rashba spin-orbit interaction at the interfacial layer. The exponential rise of thermal conductance with temperature manifests a cross-over temperature scale separating the two regimes corresponding to the opposite behaviors of the thermal conductance with the change of polarization in the ferromagnet. Inclusion of finite potential barrier at the ferromagnet-superconductor interface results in reduction of the thermal conductance whereas the interfacial Rashba spin-orbit field can enhance it resulting in a non-monotonic behavior as a function of the Rashba spin-orbit coupling. We employ scattering matrix approach to determine the amplitudes of all the quantum mechanical scattering processes possible at the interface and

the thermal conductance therein. We explain the thermoelectric properties of the hybrid structure in terms of different parameters of the system. We also investigate the Seebeck effect and show that higher thermopower can be achieved when the polarization of the ferromagnet tends towards the half-metallic limit. Whereas it can be enhanced even for lower polarization when there is a finite barrier potential at the junction. In presence of Rashba spin-orbit interaction, Seebeck co-efficient rises with the increase of barrier strength and also with the polarization at weak or moderate interfacial Rashba strength. From the application perspective, we also compute the figure of merit which can exceed 1 (zT<"4"5) with higher polarization of the ferromagnet both in absence and presence of weak Rashba spin-orbit interaction.

Paramita Dutta, Arijit Saha and A. M. Jayannavar

Fluctuation Theorems of work and entropy in Hamiltonian systems

The Fluctuation Theorems are a group of exact relations that remain valid irrespective of how far the system has been driven away from equilibrium. Other than having practical applications, like determination of equilibrium free energy change from nonequilibrium processes, they help in our understanding of the Second Law and the emergence of irreversibility from time-reversible equations of motion at microscopic level. A vast number of such theorems have been proposed in literature, ranging from Hamiltonian to stochastic systems, from systems in steady state to those in transient regime, and for both open and closed quantum systems. In this article, we discuss about a few such relations, when the system evolves under Hamiltonian dynamics.

Sourabh Lahiri and A. M. Jayannavar

Second law, Landauer's Principle and Autonomous information machine

Second law of thermodynamics can be apparently violated for systems whose dynamics depends on acquired information by measurement. However, when one consider measurement and erasure process together along with the system it saves the second law. We consider a simple example of information machine where information is used as a resource to increase its performance. The system is connected to two baths, a work source and a moving tape which is used as an information reservoir. The performance of the device is autonomous. The system acts as an engine, erasure or refrigerator. Even combination of any two is possible. All these possibilities are allowed by generalized second law.

Shubhashis Rana and A. M. Jayannavar

Emerging trends in Topological Insulator and Topological Superconductor

Topological insulators are new class of materials which are characterized by a bulk band gap like ordinary band insulator but have protected conducting states on their edge or surface. These states emerge out due to the combination of spin-orbit coupling and time reversal symmetry. Also these states are insensitive to scattering by scalar impurities. A two-dimensional (2D) topological insulator has one dimensional (1D) edge states in which the spin-momentum locking of the electrons gives rise to quantum spin Hall effect. A three-dimensional (3D) topological insulator supports novel spin-polarized 2D Dirac fermions on its surface. These topological insulator materials have been theoretically predicted and experimentally observed in a variety of 2D and

3D systems, including HgTe quantum wells, BiSb alloys, and Bi2Te3, Bi2Se3 crystals. Moreover, proximity induced superconductivity in these systems can lead to a state that supports zero energy Majorana fermion and the phase is known as topological superconductors. In this article, the basic idea of topological insulators and topological superconductors are presented along with their experimental developement.

Arijit Saha and Arun M. Jayannavar

Transport coherence in a time-asymmetric rocked ratchet model

We study the dynamics of an over damped Brownian particle in a saw tooth potential in the presence of a temporal asymmetric driving force. We observe that in the deterministic limit, the transport coherence, which is determined by a dimensionless quantity called Peclet number, *Pe* is quite high for larger spatial asymmetry in the ratchet potential. For all the regime of parameter space of this model, *Pe* follows the nature of current like Stokes efficiency. Diffusion as a function of amplitude of drive shows a minimum exactly at which the current shows a maximum. Unlike the previously studied models, the *Pe* as a function of temperature shows a peaking behavior and the coherence in transport decreases for high temperatures. In the nonadiabatic regime, the *Pe* as a function of amplitude of drive decreases and the peak gets broader as a result the transport becomes unreliable.

Mamata Sahoo and A. M. Jayannavar

Control of Decoherence in different environments : A case study for dissipative magneto-oscillator

In this paper, we analyze two different techniques based on reservoir engineering method and quantum Zeno effect for controlling decoherence of a dissipative charged oscillator in the presence of an external magnetic field. Our main focus is to investigate the sensitiveness of these decoherence control techniques on the details of different environmental spectrum ($J(\omega)$), and on the crucial role played by different system and reservoir parameters, e.g., external magnetic field (rc), confinement length ($r0$), temperature (T), cut-off frequency of reservoir spectrum (ωcut), and measurement interval (τ). First, we consider the charged quantum oscillator in an initial nonclassical Schrnodinger cat state and analyze the non-Markovian dynamics for the magneto-oscillator in contact with Ohmic, sub-Ohmic, and super-Ohmic environments. We show the procedure to control the quantumness of the Schrnodinger cat state by tuning the parameters rc, $r0$, and $J(\omega)$. On the other hand, we investigate the effect of nonselective energy measurement process on the mortification of quantumness of an initial Fock-Darwin state of the charged magneto-oscillator. We investigate in details the strategy to manipulate the continuous passage from decay suppression to decay acceleration by engineered reservoirs and by tuning the system or reservoir parameters, e.g., rc, $r0$, T or τ. As a result of that one can control environment induced decoherence (EID).

Asam Rajesh, Malay Bandyopadhyay and A. M. Jayannavar

How long does a quantum particle or wave stay in given region of space?

The delay time associated with a scattering process is one of the most important dynamical aspects in quantum mechanics. A common measure of this is the Wigner delay time based on the group velocity description of a wave-

packet, which my easily indicate super-luminal or even negative times of interaction that are unacceptable. Many other measures such as dwell times have been proposed, but also suffer from serious deficiencies, particularly for evanescent waves. One important way of realising a timescale that is causally connected to the spatial region of interest has been to utilize the dynamical evolution of extra degrees of freedom called quantum clocks, such as the spin of an electron in an applied magnetic field or coherent decay or growth of light in an absorptive or amplifying medium placed within the region of interest. Here we provide a review of the several approaches developed to answer the basic question - how much time does a quantum particle (or wave) spend in a specified region of space? While a unique answer still evades us, important progress has been made in understanding the timescales and obtaining positive definite times of interaction by noting that all such clocks are affected by spurious scattering concomitant with the very clock potentials, however, weak they be and by eliminating the spurious scattering.

S. Anantha Ramakrishna and Arun M. Jayannavar

Role of partition in work extraction from multi-particle Szilard Engine

In this work we have calculated analytically the work extraction in multi-particle Szilard engine. Unlike the previous studies, here we have introduced the biasing in the measurement procedure by inserting the partition at an arbitrary distance from the boundary. We found the work extraction to be symmetric with respect to a position- which is half way between the boundary walls. The work extraction is also calculated as a function of number of particles and it shows to saturate to a certain value for large number of particles. We find that work extraction can be made larger for multi-particle engine when the partition is inserted in the middle.

P. S. Pal and A. M. Jayannavar

Single Particle Brownian Heat Engine WithMicroadiabaticity

Micro-to-nano scale thermal devices that operate under large thermal fluctuations, are an active field of research where instead the average values, the full distributions of thermodynamic quantities are important. Here we study a model of stochastic heat engine consisting of a harmonically trapped Brownian particle driven by the time-periodic strength of the confinement, within two thermal baths of different temperatures. The particle follows two isotherms correspond to two baths and connected by two micro-adiabates. The microadiabaticity is implemented by conserving the phase space volume of the particle along the adiabatic paths. Here we show that it can operate as an engine or as a heater under microadiabaticity, depending on the parameter space. We also compute the distribution of stochastic efficiency and its averages for different cycle times of the engine.

Arnab Saha and A. M. Jayannavar

Barrierless reaction kinetics : Inertial effect on different distribution functions of relevant Brownian functionals

We investigate the effect of inertia on barrierless electronic reactions in solution by suggesting and examining different probability distribution functions (PDF) of relevant Brownian functionals associated with the lifetime and reactivity of the process. Activationless electronic reaction in solution can be modeled as a free Brownian motion with inertial term in the

underdamped regime. In this context we suggest several important distribution functions that can characterize the reaction kinetics. Most of the studies on Brownian functional which has vast potential application in diverse fields, are confined in the overdamped regime. To the best of our knowledge, we are attempting first time to incorporate the much important inertial effects on the study of different PDFs related with Brownian functionals of an underdamped Brownian motion with time dependent drift and diffusion coefficients using celebrated backward Fokker-Planck and path decomposition methods. We have explored nontrivial scaling behaviour of different PDFs and calculated explicitly the critical exponents related with the asymptotic limits in time.

Ashutosh Dubey, Malay Bandyopadhyay and A. M. Jayannavar

Interacting Multi-particle Classical Szilard Engine

Szilard engine(SZE) is one of the best example of how information can be used to extract work from a system. Initially, the working substance of SZE was considered to be a single particle. Later on, researchers has extended the studies of SZE to multi-particle systems and even to quantum regime. Here we present a detailed study of classical SZE consisting of N particles with inter-particle interactions, i.e., the working substance is a low density non-ideal gas and compare the work extraction with respect to SZE with non-interacting multi particle system as working substance. We have considered two cases of interactions namely: (i) hard core interactions and (ii) square well interaction. Our study reveals that work extraction is less when more particles are interacting through hard core interactions. More work is extracted when the particles are interacting via square well interaction. Another important result for the second case is that as we increase the particle number the work extraction becomes independent of the initial position of the partition, as opposed to the first case. Work extraction depends crucially on the initial position of the partition. More work can be extracted with larger number of particles when partition is inserted at positions near the boundary walls.

P. S. Pal and A. M. Jayannavar

Transport and noise properties of a normal metal"superconductor"normal metal junction with mixed singlet and chiral triplet pairings

We study transport and zero frequency shot noise properties of a normal metal-superconductor normal metal (NSN) junction, with the superconductor having mixed singlet and chiral triplet pairings. We show that in the subgapped regime when the chiral triplet pairing amplitude dominates over that of the singlet, a resonance phenomena emerges out at zero energy where all the quantum mechanical scattering probabilities acquire a value of 0.25. At the resonance, crossed Andreev refiection mediating through such junction, acquires a zero energy peak. This refiects as a zero energy peak in the conductance as well depending on the doping concentration. We also investigate shot noise for this system and show that shot noise cross-correlation is negative in the subgapped regime when the triplet pairing dominates over the singlet one. The latter is in sharp contrast to the positive shot noise obtained when the singlet pairing is the dominating one.

Ganesh C. Paul, Paramita Dutta, Arijit Saha

Thermal conductance by Dirac fermions in a normal- insulator- superconductor junction of silicene

We theoretically study the properties of thermal conduct anceina normal- insulator-superconductor junction of silicene for both thin and thick barrier limit. We show that while thermal conductance displays the conventional exponential dependence on temperature, it manifests anontrivial oscillatory dependence on the strength of the barrier region. The tunability of the thermal conductance by an external electric field is also investigated. Moreover, we explore the efiect of doping concentration on thermal conductance. In the thin barrier limit, the period of oscillations of the thermal conductance as a function of the barrier strength comes out be $\pi/2$ when doping concentration in the normal silicene region is small. On the other hand, the period gradually converts to π with the enhancement of the doping concentration. Such change of periodicity of the thermal response with doping can be a possible probe to identify the crossover from specular to retro Andreev refiection in Dirac materials. In the thick barrier limit, thermal conductance exhibits oscillatory behavior as a function of barrier thickness d and barrier height V0 while the period of oscillation becomes V0 dependent. However, amplitude of the oscillations, unlike in tunneling conductance, gradually decays with the increase of barrier thickness for arbitrary height V0 in the highly doped regime. We discuss experimental relevance of our results.

Ganesh C. Paul, Surajit Sarkar, Arijit Saha

Tunneling Conductance in Normal-Insulator-Superconductor junctions of Silicene

We theoretically investigate the transport properties of a normal-insulator-superconductor (NIS) junction of silicene in the thin barrier limit. Similar to graphene the tunneling conductance in such NIS structure exhibits an oscillatory behavior as a function of the strength of the barrier in the insulating region. However, unlike in graphene, the tunneling conductance in silicene can be controlled by an external electric field owing to its buckled structure. We also demonstrate the change in behavior of the tunneling conductance across the NIS junction as we change the chemical potential in the normal silicene region. In addition, at high doping levels in the normal region, the period of oscillation of the tunneling conductance as a function of the barrier strength changes from $\pi/2$ to π with the variation of doping in the superconducting region of silicene.

Surajit Sarkar, Arijit Saha, Suhas Gangadharaiah

Quantum charge pumping through resonant crossed Andreev refiection in superconducting hybrid junction of Silicene

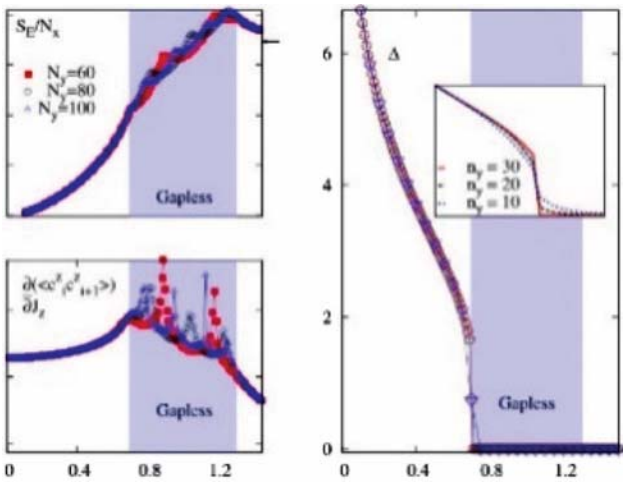
We theoretically investigate the phenomena of adiabatic quantum charge pumping through a normal-insulator-superconductor-insulator-normal (NISIN) setup of silicene within the scattering matrix formalism. Assuming thin barrier limit, we consider the strength of the two barriers ($\chi1$ and $\chi2$) as the two pumping parameters in the adiabatic regime. Within this geometry, we obtain crossed Andreev refiection (CAR) with probability unity in the $\chi1-\chi2$ plane without concomitant transmission or elastic cotunneling (CT). Tunability of the band gap at the Dirac point by applying an external electric field perpendicular to the silicene sheet and variation of the chemical potential at the normal silicene region, open up the possibility of achieving perfect either CAR or transmission

process through our setup. This resonant behavior is periodic with the barrier strengths. We analyze the behavior of the pumped charge through the NISIN structure as a function of the pumping strength and angles of the incident electrons. We show that large (Q ~ 2e) pumped charge can be obtained through our geometry when the pumping contour encloses either the CAR or transmission resonance in the pumping parameter space. We discuss possible experimental feasibility of our theoretical predictions.

Ganesh C. Paul, Arijit Saha

Study of Entanglement and Majorana edge states in the Kitaev model

We investigated the von Neumann entanglement entropy and Schmidt gap in the vortex-free ground state ofthe Kitaev model on the honeycomb lattice for square/rectangular and cylindrical subsystems. We find that,for both the



subsystems, the free-fermionic contribution to the entanglement entropy SE exhibits signaturesof the phase transitions between the gapless and gapped phases. However, within the gapless phase, we findthat SE does not show an expected monotonic behavior as a function of the coupling Jz between the suitablydefined one-dimensional chains for either geometry; moreover, the system generically reaches a point of minimum entanglement within the gapless phase before the entanglement saturates or increases again until the gapped phaseis reached. This may be attributed to the onset of gapless modes in the bulk spectrum and the competition between the correlation functions along various bonds. In the gapped phase, on the other hand, SE always monotonicallyvaries with Jz independent of the subregion size or shape. Finally, further confirming the Li-Haldane conjecture,we find that the Schmidt gap defined from the entanglement spectrum also signals the topological transitionsbut only if there are corresponding zero-energy Majorana edge states that simultaneously appear or disappearacross the transitions.We analytically corroborate some of our results on entanglement entropy, the Schmidt gap and the bulk-edge correspondence using perturbation theory.

Saptarshi Mandal, Moitri Maiti, and Vipin Kerala Varma

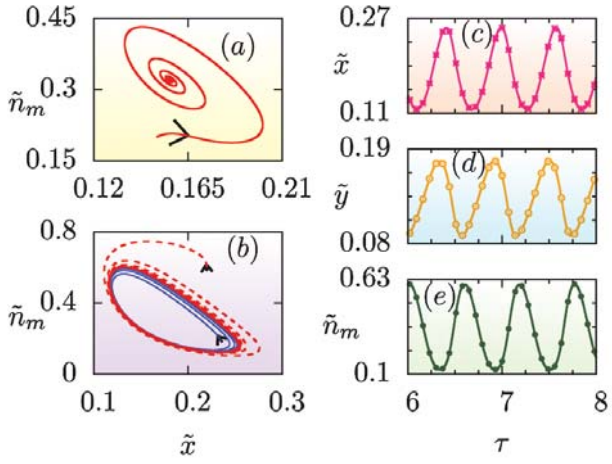
Entanglement studies in Kitaev model

We have studied entanglement entropy and entanglement gap in Kitaev modelfor rectangular/square region and half region subsystem. For both the geometry it is found that the entanglement entropy is not monotonous in gapless phase and monotonous in gapped Phase, apart from the usual non monotonicity inthe

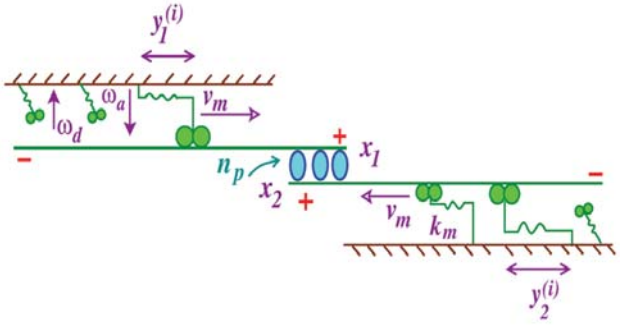
vicinity of phase transition. For entanglement gap, we have found that itis gapless whenever there is a gapless edge mode in the boundary irrespective of whether the bulk mode is gapless or gapped.

Saptarshi Mandal and collaborators

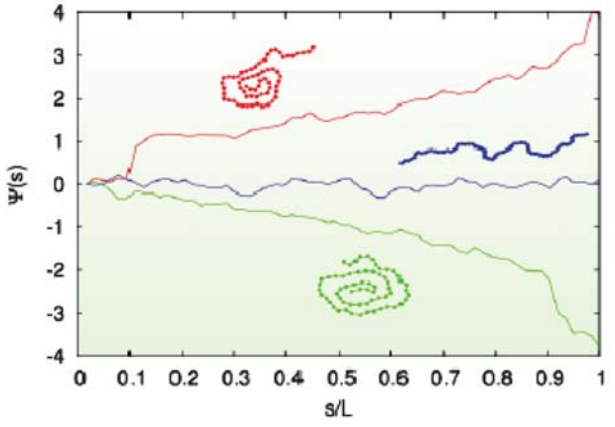
Active filaments: In eukaryotic cells, motor proteins (MP) bind to cytoskeletal filaments and



move along them in a directed manner generating active stresses. We consider a molecular motor assay of semiflexible filaments driven by molecular motors attached irreversibly to a surface. Under the active drive, structural and

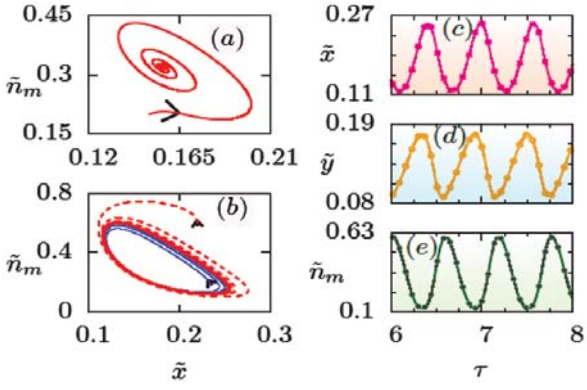


mechanical properties of polymer change dramatically. This is characterized by a distribution of endto-end vector, local tangent

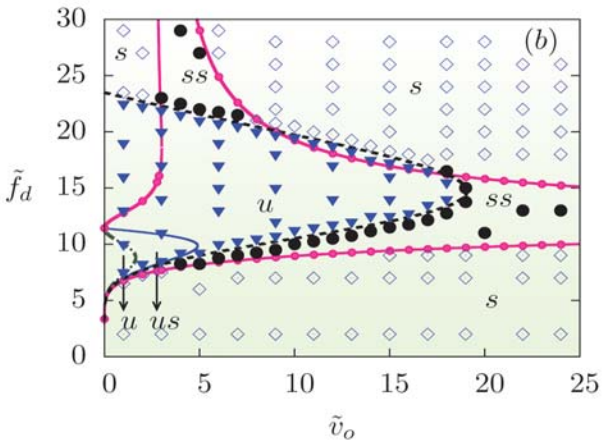


correlations, and the distribution of a spiral order parameter ø(s). Activity both stiffens and softens the polymer — attachment detachment dynamics generates softening captured by a Gaussian like end-to-end distribution, while increased sliding activity affects the bending stiffness in a non-monotonic manner. The relatively extended state of the polymer is motile whereas the center of mass gets localized in the spiral state. This is an ongoing work.

During cell division a spindle structure of overlapping antiparallel microtubules (MT) form whose stability and dynamics under the influence of MPs has been studied extensively. Although



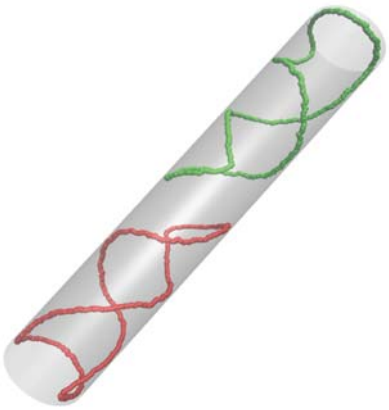
passive cross linkers (PCL) were known to provide structural stability to filamentous



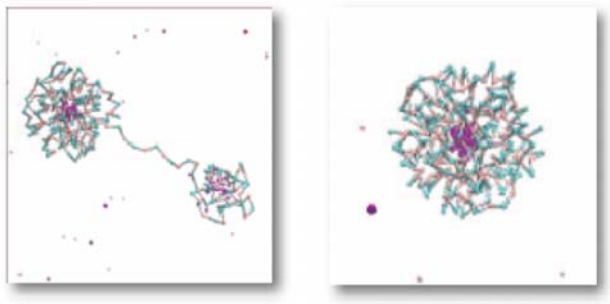
network, consequences of the interplay between ATP dependent active forces of MPs and entropic forces of PCLs on MT overlap remained largely unexplored. We have formulated and characterized a model using linear stability analysis and numerical integration to study this overlap dynamics. With changing activity, in the presence of PCLs, we found dynamic phase transitions exhibiting regimes of linearly or oscillatory stable behavior, instability towards complete overlap, and a regime of stable limit cycle oscillation that emerges via a supercritical Hopf bifurcation and is characterized by an oscillation frequency determined by the MP and PCL parameters. We showed that the overlap dynamics and stability depends crucially on whether both the MTs of overlapping pair are motile or one is immobilized, having important implications for experimental studies. In a cell overlapping MTs may remain motile or immobilized via bonds with a background of cytoskeletal matrix.

D. Choudhuri and collaborators

Bacterial Chromosome: Although bacteria are the simplest form of life, very little is understood about its life processes. A typical micron sized rod-shaped bacteria contains a membrane-less nucleoid that consists of a single circular DNA of mm length compacted by several associated proteins. The nucleoid shows a ubiquitous helicoid shape. The size and shape of nucleoid is intricately related to gene translation



and transcription. Using coarse grained modeling and experiments (collaboration with the TU-Delft group of Cess Dekker), we have been asking fundamental questions regarding the emergence

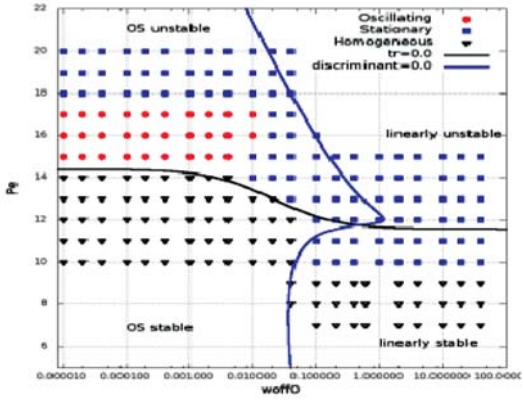


of local structures, its relation to the overall morphology, mechanisms of chromosome positioning and segregation during cell division. We proposed and characterized a polymer-based featherboa model of chromosome. Entropic effects associated with self-avoidance of the polymer, crowing due to cytosol and cellular confinement captures experimentally observed size and shape changes, dynamics, positioning and chromosome segregation quantitatively. Using a physical model of polymer and cross-linking diffusing elements, we are currently

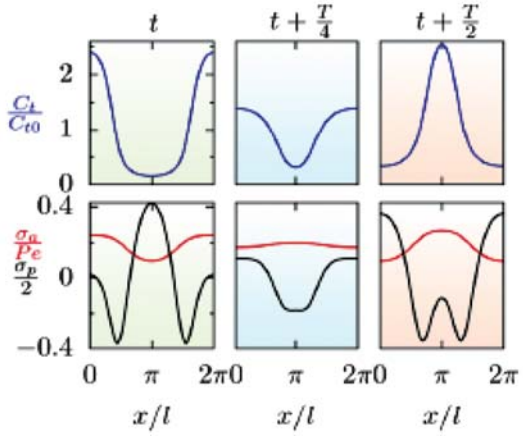
studying the dynamics of loop formation in bacterial DNA.

D. Choudhuri and collaborators

Phase transition in active fluid : Active processes in cell biology is known to give rise to patterns, associated with stress generation and



dynamics. Examples could be found in cytoskeleton, leading edge of motile cells, filopodial and lamellepodial dynamics in neural growth cone, and pulsatile pattern in



cytoskeleton. We study a compressible fluid switching between active and passive fraction where the total concentration is conserved. A competition between the active contractile stress and differential diffusivity controls the pattern formation. We obtained a phase diagram as a function of switching rate between the two components, and contractile activity. Depending on parameter values one finds three phases — uniform fluid, static patterns, and active oscillatory pattern in the final steady state.

D. Choudhuri and collaborators

Spinfiltering and switching action in a diamond network with magnetic-nonmagnetic atomic distribution.

We propose a model of quantum network and demonstrate possible scenarios for production of spinfiltering and switching action in a diamond network with magnetic-nonmagnetic atomic distribution. Our model consists of diamond-shaped plaquettes with deterministic distribution of magnetic and non-magnetic atoms in presence of a uniform external magnetic fiux in each plaquette. The orientations and the amplitudes of the substrate magnetic moments play a crucial role in the energy band engineering of the two spin channels which essentially gives us a con

trol over the spin transmission leading to a spin-filtering efiect. The externally tunable magnetic fiux plays an important role in inducing a switch on-switch or switch-ofi efiect for both the spin states indicating the behavior like a spintronic switch. Even a correlated disorder configuration in the on-site potentials and in the magnetic moments may lead to disorder-induced spin-filtering phenomenon where one of the spin channel gets entirely blocked leaving the other one transmitting over the entire allowed energy regime. All these features are established by evaluating the density of states and the two terminal transmission probabilities using the transfer-matrix formalism within a tight-binding framework.

Biplab Pal and Paramita Dutta.

3.2 Theoretical High Energy Physics

At IOP, we are actively pursuing cutting edge research in the following three branches of High Energy Physics (HEP).

High Energy Physics Phenomenology

The High Energy Physics (HEP) Phenomenology plays an important role at the energy, intensity, and cosmic frontiers to unravel the deep long-standing mysteries of the Universe. We are performing an active research in this field with a special emphasis on collider physics, neutrino physics, and dark matter. We are devoting considerable amount of time to explore the physics beyond the Standard Model at the ongoing LHC experiment, and to study the physics reach of the proposed ILC experiment. The India-based Neutrino Observatory (INO) is a flagship mega-science project of India to study the fundamental properties of Neutrinos. We are actively involved in the physics and detector simulation studies related to the Iron Calorimeter (ICAL) detector at the INO facility. We are also contributing towards the research activities related to 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 experiment being carried out at LHC and RHIC. We are performing extensive simulations related to quark-hadron phase transitions, and magneto-hydrodynamics to understand the flow dynamics using the HPC facility of our Institute. At IOP, we have been carrying out tabletop liquid crystal experiments which can provide tests of theories of cosmic defects. Our research has provided a quantitative basis for this correspondence by focusing on the universal aspects of predictions from cosmological theories. The group members are also spending time to explore the emerging issues in astroparticle physics like dark matter, dark energy, baryogenesis, gravitational waves etc.

String Theory :

String theory is one of the most active area of research worldwide. It shows a lot of promise to find a quantum theory of gravity, introduce new techniques and throw light at a number of other issues. The group members have interest in classical and quantum black holes, cosmology, find realistic stable vacua with broken supersymmetry, application of gauge-gravity duality to strongly coupled gauge theories.

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

Bell violation in primordial cosmology

In this paper, we have worked on the possibility of setting up an Bell's inequality violating experiment in the context of primordial cosmology following the fundamental principles of quantum mechanics. To set up this proposal, we have introduced a model-independent theoretical framework using which we have studied the creation of new massive particles for the scalar fluctuations in the presence of an additional time-dependent mass parameter. Next we explicitly computed the one-point and two-point correlation functions from this setup. Then, we comment on the measurement techniques of isospin breaking interactions of newly introduced massive particles and its further prospects. After that, we give an example of the string theory-originated axion monodromy model in this context. Finally, we provide a bound on the heavy particle mass parameter for any arbitrary spin field.

Sayantan Choudhury, Sudhakar Panda, Rajeev Singh.

Bell violation in the Sky

In this work, we have studied the possibility of setting up Bell's inequality violating experiment in the context of cosmology, based on the basic principles of quantum mechanics. First we start with the physical motivation of implementing the Bell's inequality violation in the context of cosmology. Then to set up the cosmological Bell violating test experiment we introduce a model independent theoretical framework using which we have studied the creation of new massive particles by implementing the WKB approximation method for the scalar fluctuations in presence of additional time dependent mass contribution. Next using the background scalar fluctuation in presence of new time dependent mass contribution, we explicitly compute the expression for the one point and two point correlation functions. Furthermore, using the results for one point function we introduce a new theoretical cosmological parameter which can be expressed in terms of the other known inflationary observables and can also be treated as a future theoretical probe to break the degeneracy amongst various models of inflation. Additionally, we also fix the scale of inflation in a model independent way without any prior knowledge of primordial gravitational waves. Next, we also comment on the technicalities of measurements from isospin breaking interactions and the future prospects of newly introduced massive particles in cosmological Bell violating test experiment. Further, we cite a precise example of this set up applicable in the context of string theory motivated axion monodromy model. Then we comment on the explicit role of decoherence effect and high spin on cosmological Bell violating test experiment. In fine, we provide a theoretical bound on the heavy particle mass parameter for scalar fields, graviton and other high spin fields from our proposed setup.

Sayantan Choudhury, Sudhakar Panda, Rajeev Singh.

COSMOS-e' - G Tachyon from string theory

In this article, our prime objective is to study the inflationary paradigm from generalized tachyon (GTachyon) living on the world volume of a non-BPS string theory. The tachyon action is considered here is getting modified compared to the original action. One can quantify the amount of the modification via a power q instead of 1/2 in the effective action. Using this set up we study inflation from various types of tachyonic potentials, using which we constrain the index q within, $1/2<q<2$, Regge slope α', string coupling constant g_s and mass scale of tachyon M_s, from the recent Planck 2015 and Planck+BICEP2/Keck

Array joint data. We explicitly study the inflationary consequences from single field, assisted field and multi-field tachyon set up. Specifically for single field and assisted field case we derive the results in the quasi-de-Sitter background in which we will utilize the details of cosmological perturbations and quantum fluctuations. Also we derive the expressions for all inflationary observables using any arbitrary vacuum and Bunch-Davies vacuum. For single field and assisted field case we derive-the inflationary flow equations, new sets of consistency relations. Also we derive the field excursion formula for tachyon, which shows that assisted inflation is in more safer side compared to the single field case to validate effective field theory framework. Further we study the features of CMB Angular power spectrum from TT, TE and EE correlations from scalar fluctuations within the allowed range of q for each potentials from single field set-up. We also put constraints from the temperature anisotropy and polarization spectra, which shows that our analysis is consistent with the Planck 2015 data. Finally, using $\boldsymbol{\delta}N$ formalism we derive the expressions for inflationary observables in the context of multi-field tachyons.

Sayantan Choudhury and Sudhakar Panda

Relativistic Heavy-Ion Collisions :

Magnetohydrodynamics Simulation in relativistic heavy-ion collisions, fiuctuations and enhancement of magnetic field

We carry out magnetohydrodynamics simulations to study the effects of initial magnetic field on the evolution of the plasma in the presence of initial state fluctuations. Our results show that magnetic field has complex effect on elliptic flow leading to enhancement for small impact parameters and suppression for large impact parameters. We find that initial state fiuctuations can lead to magnetic field rearrangements leading to temporary increase of the magnetic field.

A.Das, S.S. Dave, P.S. Saumia and A. M. Srivastava

Superfluid vortices in high baryon density QGP and Dynamo effect

QCD phase diagram allows for exotic phases at high baryon density. Some of these allow for superfluidity. We investigate the possibility of turbulence caused by formation of such superfiuid vortices and its effect on the initial magnetic field in QGP. We show the possibility of dynamo effect in relativistic heavy-ion collisions arising from these vortices.

A.Das, S.S. Dave, P.S. Saumia and A. M. Srivastava

Magnetohydrodynamics Simulation of deformed nucleus collision and quadrupole focusing of QGP expansion

Collisions of Deformed nuclei (e.g. uranium) allow for nontrivial shape dependent magnetic field in relativistic heavy-ion collisions. We show anomalous elliptic flow in these collisions which can be used to detect initial magnetic field. We also show that for special geometries of collisions a quadrupole magnetic field can arise which leads to focusing efiect on QGP expansion.

A.Das, S.S. Dave, P.S. Saumia and A. M. Srivastava

Adiabaticity violation and Quarkonia Disintegration due to spatial and temporal fluctuations in in Relativistic Heavy Ion Collisions

Continuing project: We study adiabaticity violation of J/Ψ evolution dueto spatial and temporal variations of energy density in relativistic heavy-ion collisions by calculating the

survival probability of J/Ψ and **Υ** using time dependent perturbation theory.

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

Disintegration of quarkonia due to dependence of quark masses on Polyakov loop in Relativistic Heavy Ion Collisions

Continuing project: Non-trivial profile of the Polyakov loop of the Z(3) domain walls in QGP leads to spatially varying efiective mass of the quarks. We study the interaction of Upsilon with Z(3) interfaces which disintegrates quorkonia by exciting it to higher states of $q^{-}q$ system.

A. Atreya, P. Bagchi, and A. M. Srivastava

Cosmology

Effects of random density fiuctuations on pulsar dynamics, glitches and pulse modulation

We model density fluctuations arising from phase transitions in terms of a random matrix and study its effects on pulsar dynamics. We study resulting changes in pulse timings which can account for glitches and study its correlations with the modulation of pulse profiles. We also estimate resulting gravitational wave intensity.

P. Bagchi, A. Das, B. Layek, and A. M. Srivastava

Initial conditions for inflation, Reaction difiusion equation, and correlation domains

We address the issue of severe fine tuning of initial field values required for inflation models using reaction-diflusion (RD) equations. We show that the inflaton field, with appropriate profile in a domain of order correlation size can expand leading to vacuum energy dominance in the Hubble volume allowing the region to enter infiationary stage successfully.

P. Bagchi, A. Das, S.S. Dave, S. Sengupta, and A. M. Srivastava

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.

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

Liquid Crystal Experiments

Nematic to isotropic phase transition with memory effect of strings in liquid crystals

In isotropic to nematic transition string defects are formed. We have found that in the reverse transition, the molecular ordering appears to not become totally random near the original string defects. These leads to enhanced bubble formation of nematic phase in the isotropic-nematic transition near the location of original string. This represents a possible memory effect for liquid crystal transitions near the boundary of the transition.

Ajit M. Srivastava

Production of three bosons through gluon-gluon fusion at the Hadron Colliders

We have calculated one-loop amplitudes for the production of Higgs boson in associationwith two electroweak bosons *(H,γ,Z)* via gluon-gluon fusion. We have computed the totalcross section and distributions at 8, 13 and 100 TeV center-of-mass energies at *pp* colliders.We study the interference effect and, also investigate the efiect of new physics in terms ofanomalous couplings of the Higgs boson in these processes, in

particular the presence of the anomalous *tth, hhh, hhhh,* and *zzh* interactions. The process $pp \to hhh$ takes place at oneloop via pentagon, box and triangle diagrams. For the process $pp \to hhZ$, we have computed the NNLO corrections. For these corrections, we have again computed a set of one-loopdiagrams. We find that the anomalous couplings can enhance the cross sections significantly.

P. Agrawal, Debashis Saha and Ambresh Shivaji

A Few Finite Trigonometric Sums

Finite trigonometric sums occur in various branches of physics, mathematics, and their applications. These sums may contain various powers of one or more trigonometric functions.Sums with one trigonometric function are known; however, sums with products of trigonometric functions can become complicated, and may not have a simple expression in a numberof cases. Some of these sums have interesting properties, and can have amazingly simplevalues. However, only some of them are available in the literature. We obtain a number ofsuch sums using the method of residues.

P. Agrawal and Chandan Datta

AdS/CFT correspondence and time-dependent backgrounds

Several time dependent backgrounds, with perfect fluid matter, can be usedto construct solutions of Einstein equations in the presence of a negativecosmological constant along with some matter sources. We focus on thenon-vacuum Kasner-AdS geometry and its solitonic generalization. Tocharacterize these space-times, we provide ways to embed them in higher dimensional flat space-times. General space-like geodesics are thenstudied and used to compute the two point boundary correlators within thegeodesic approximation.

S. Mukherji, Soumyabrata Chatterjee, Sudipto Paul Chowdhury, Yogesh K. Srivastava

Internal Structure of Charged AdS Black Holes

When an electrically charged black hole is perturbed its inner horizonbecomes a singularity, often referred to as the Poisson-Israel massinflation singularity. Ori constructed a model of this phenomenon for a symptotically flat black holes, in which the metric can be determined explicitly in the mass inflation region. In this paper we implement the Orimodel for charged AdS black holes. We find that the mass function inflatesfaster than the flat space case as the inner horizon is approached. Nevertheless, the mass inflation singularity is still a weak singularity: although spacetime curvature becomes infinite, tidal distortions remainfinite on physical objects attempting to cross it.

Srijit Bhattacharjee, Sudipta Sarkar, Amitabh Virmani

Hair on non-extremal D1-D5 bound states

We consider a truncation of type IIB supergravity on four-torus where inaddition to the Ramond-Ramond 2-form field, the Ramond-Ramond axion (w) andthe NS-NS 2-form field (B) are also retained. In the (w, B) sector weconstruct a linearised perturbation carrying only left moving momentum ontwo-charge non-extremal D1-D5 geometries of Jejjala, Madden, Ross andTitchener. The perturbation is found to be smooth everywhere andnormalizable. It is constructed by matching to leading order solutions ofthe perturbation equations in the inner and outer regions of the geometry.

Pratik Roy, Yogesh K. Srivastava, Amitabh Virmani

Oscillating Shells and Oscillating Balls in AdS

It has recently been reported that certain thin timelike shells undergooscillatory motion in AdS. In this paper, we compute two-point function ofa

probe field in the geodesic approximation in such an oscillating shellbackground. We confirm that the two-point function exhibits an oscillatory behaviour following the motion of the shell. We show that similaroscillatory dynamics is possible when the perfect fluid on the shell has apolytropic equation of state. Moreover, we show that certain ball likeconfigurations in AdS also exhibit oscillatory motion and comment on howsuch a solution can be smoothly matched to an appropriate exteriorsolution. We also demonstrate that the weak energy condition is satisfiedfor these oscillatory configurations.

Avik Banerjee, Arnab Kundu, Pratik Roy, Amitabh Virmani

Octant of θ_{23} in danger with a light sterile neutrino

Present global fits of world neutrino data hint towards non-maximal θ_{23} with two nearly degenerate solutions, one in the lower octant ($\theta_{23} < \pi/4$), and the other in the higher octant ($\theta_{23} > \pi/4$). This octant ambiguity of θ_{23} is one of the fundamental issues in the neutrino sector, and its resolution is a crucial goal of next-generation long-baseline (LBL) experiments. In this letter, we address for the first time, the impact of a light eV-scale sterile neutrino towards such a measurement, taking the Deep Underground Neutrino Experiment (DUNE) as a case study. In the so-called 3+1 scheme involving three active and one sterile neutrinos, the $\nu_\mu \rightarrow \nu_e$ transition probability probed in the LBL experiments acquires a new interference term via active-sterile oscillations. We find that this interference term can mimic a swap of the θ_{23} octant, even if one uses the information from both neutrino and antineutrino channels. As a consequence, the sensitivity to the octant of θ_{23} can be completely lost, and this may have serious implications for our understanding of neutrinos from both the experimental and theoretical perspectives.

Sanjib Kumar Agarwalla, Sabya Sachi Chatterjee, Antonio Palazzo

Degeneracy between q_{23} octant and neutrino non-standard interactions at DUNE

We expound in detail the degeneracy between the octant of θ_{23} and flavorchanging neutral-current non-standard interactions (NSI's) in neutrino propagation, considering the Deep Underground Neutrino Experiment (DUNE) as a case study. In the presence of such NSI parameters involving the e-μ ($\varepsilon_{e\mu}$) and e-τ ($\varepsilon_{e\tau}$) flavors, the $\nu_\mu \rightarrow \nu_e$ and $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ appearance probabilities in long-baseline experiments acquire an additional interference term, which depends on one new dynamical CP-phase $\varphi_{e\mu/e\tau}$. This term sums up with the well-known interference term related to the standard CP-phase δ creating a source of confusion in the determination of the octant of θ_{23}. We show that for values of the NSI coupling (taken one at-a-time) as small as few% (relative to the Fermi coupling constant GF), and for unfavorable combinations of the two CP-phases δ and $\varphi_{e\mu/e\tau}$, the discovery potential of the octant of θ_{23} gets completely lost.

Sanjib Kumar Agarwalla, Sabya Sachi Chatterjee, Antonio Palazzo

Indirect searches of Galactic deffuse dark matter in INO-MagICAL detector

The signatures for the existence of dark matter are revealedonly through its gravitational interaction. Theoretical arguments support that the Weakly Interacting MassiveParticle(WIMP) can be a class of dark matter and it can annihilate and/or decay to Standard Model particles, among which neutrino is a favorable candidate. We show that the proposed 50 kt MagnetizedIron CAL orimeter (MagICAL) detector under the

India-based Neutrino Observatory (INO) project can play an important role in the indirect searches of Galactic diffuse dark matter in the neutrino and antineutrino mode separately. We present the sensitivity of 500 kt·yr MagICAL detector to set limits on the velocity-averaged self-annihilation crosssection (<σvi>) and decay lifetime (τ) of dark matter having mass in the range of 2 GeV ≤ m_χ ≤ 90 GeV and 4 GeV ≤ m_χ ≤ 180 GeV respectively, assuming no excess over the conventional atmospheric neutrino and antineutrino fiuxes at the INO site. Our limits for low mass dark matter constrain the parameter space which has not been explored before. We show that MagICAL will be able to set competitive constraints, <σv> ≤ 1.87× 10^{-24} cm^3 s^{-1} for $\chi\chi \rightarrow \nu^- \nu$ and $\tau \geq 4.8\times10^{24}$s for $\chi \rightarrow \nu^- \nu$ at 90% C.L. (1 d.o.f.) for m_χ= 10 GeV.

Amina Khatun, Ranjan Laha, Sanjib Kumar Agarwalla

Black holes in asymptotically Anti de-Sitter (AdS) space

My main research interest is Black Holes. In particular, for the last one year I have been studying black holes in asymptotically Anti de-Sitter (AdS) spaces using a non-perturbative formulation of string theory called AdS-CFT correspondence. The correspondence says that string theory on AdS space can equally well be described by an ordinary Conformal Field Theory (CFT) living on the boundary of AdS. This non-perturbative duality is very useful for studying various questions like black hole entropy and some questions related to information loss. My research focusses on understanding the space-like curvature singularity which is hidden behind the horizon of the black hole. In our previous work we have shown that from the point of view of holographic renormlization group curvature singularity can be thought of as a trivial infrared fixed point of a gapped system. In this case the gapped system is the thermal state in the boundary CFT which is dual to the black hole. We have conjectured that the information theoretic quantity called "logarithmic entanglement negativity" plays the role of c-function in the thermal state. Therefore the long-distance expansion of the logarithmic negativity in a finite temperature state carries information about the physics near the curvature singularity. My recent research has shown that the above description of the curvature singularity is only true "approximately". This is related to the fact that although information theoretic quantities are computable but still they are not observables in quantum mechanics. This gives us a better perspective on the singularity. The picture that we suggest has two parts. Firstly, the classical singularity is resolved due to the non-locality of the theory. In a nutshell, the classical or effective field theory questions that we usually ask about the singularity do not have any answer if use the exact observables of the theory. In this case the exact observables are the correlation functions of the CFT. This can be thought of as the resolution of the classical singularity. The second part is related to the breakdown of the effective field theory in the near-horizon region. Due to the non-locality of the theory Planck scale effects which are supposed to be localized in the region near the singularity become visible in the near-horizon region. This may be called UV-IR mixing. The expected magnitude of such Planck scale efiects in the near-horizon region is of order e"S where S is the black hole entropy. These small Planck scale efiects should carry all the informationabout the singularity and the surprising fact is that our arguments suggest that these tiny Planck scale efiects should be visible to a low-energy observer.

S. Banerjee and collaborators.

3.3 Theoretical nuclear physics

Theoretical nuclear physics is the development of models for describing the nucleus and the processes that occur within it. This includes understanding the shape of the nucleus, or why nuclei with certain numbers (so-called magic numbers) of protons or neutrons are more stable than others. The theory group works in subjects which are important from a pure theoretical point of view as well as for the interpretation and development of experiments which are being carried out in various laboratories around the world.

The group works on topics that range from low-energy nuclear structure to the frontier where nuclear and particle physics overlap. Our current interests are focussed on "fundamental" approaches to nuclear physics, with the ultimate goal of linking it to quantum chromodynamics (QCD) - the underlying theory of the strong interaction. We have particular expertise in the areas of effective field theory and in microscopic many-body theory.

There are two main strands to our work. One is relating the structure and interactions of nucleons and mesons to QCD. Here we are interested in the key role played by the symmetries of QCD, especially the chiral symmetry which encodes the fact that up and down quarks have very small masses. This work makes use of tools from quantum field theory, in particular effective field theories and the renormalization group. The second strand is the calculation of the structure and properties of nuclei starting from forces between nucleons in vacuum. This uses techniques from few-body physics and microscopic many-body theory, such as the coupled-cluster method.

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

Tidal deformability of neutron and hyperon star with relativistic mean field equations of state

We systematically study the tidal deformability [??] for neutron and hyperon stars using relativistic mean field (RMF) equations of state (EOSs). The tidal effect plays an important role during the early part of the evolution of compact binaries. Although, the deformability associated with the EOSs has a small correction, it gives a clean gravitational wave signature in binary inspiral. These are characterized by various Love numbers k_l *(l=2, 3, 4)*, that depend on the EOS of a star for a given mass and radius. The tidal efiect of star could be eficiently measured through advanced LIGO detector from the final stages of inspiraling binary neutron star (BNS) merger.

S. K. Patra and Collaborators

Structure efiects on fission yields

The structure efiects of the fission fragments on their yields are studied within the statistical theory with the inputs, like, excitation energies and level density parameters for the fission fragments at a given temperature calculated using the temperature dependent relativistic mean field formalism (TRMF). For the comparison, the results are also obtained using the finite range droplet model. At temperatures *T = 1"2* Men, the structural efiects of the fission fragments infiuence their yields. It is also seen that at *T = 3* MeV, the fragments become spherical and the fragments distribution peaks at a close shell or near close shell nucleus.

S. K. Patra and Collaborators

New parameterization of the efiective field theory motivated relativistic mean field model

A new parameter set is generated for finite and infinite nuclear system within the efiective field theory motivated relativistic mean field (ERMF) formalism. The isovector part of the ERMF model employed in the present study includes the coupling of nucleons to the **δ** and **ρ** mesons and the crosscoupling of **ρ** mesons to the **σ** and **ω** mesons. The results for the finite and infinite nuclear systems obtained using our parameter set are in harmony with the available experimental data. We find the maximum mass of the neutron star to be 2.03M and yet a relatively smaller radius at the canonical mass, 12.69 km, as required by the available data.

S. K. Patra and Collaborators

ALICE Collaboration:

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.

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

Some hadronic resonance states due to their short lifetimes (~few fm/c)are important to

investigate some properties like the time span of the hadronic scattering medium formed in relativistic heavy-ion collisions. In particular, the **Λ(1520** (commonly known as **Λ*** baryonic resonance is important because its lifetime (~12.6 fm/c) is comparable to the time scale of the hot and dense matter produced in heavy-ion collisions.The characteristic properties such as mass, width, yield and transverse momentum spectra of **Λ*** may be very sensitive to the dynamics and in-medium effects. Basically th decay products of **Λ*** the protons and kaons, may undergo in-medium effects such as re-scattering. The re-generation process (pseudo-elastic interactions; p+K → **Λ*** → p+K) may compensate for the **Λ*** yield, lost in re-scattering, if the system formed has a long expansion time.

We have studied production of **Λ** in p-p and p-Pb collisions at 7 TeV and 5.02 TeV, respectively. In p-p collisions the signal is extracted in the mid rapidity window ($|y| = 0.5$), but due to asymmetric collision of p and Pb, the signal in extracted in rapidity, $-0.5 < y < 0$. We have calculated the p_T- integrated yield and $\langle p_T \rangle$ in case of inelastic p-p collisions, Non-Single Diffracted (NSD) p-Pb collisions and in different charged particle multiplicity bins in p-Pb collisions. These measured values are compared with other resonances as well as long lived particles. We have the following findings from this study.

Λ* follows mass ordering in $\langle p_T \rangle$for both p-p and p-Pb collisions.

Λ* Strangeness content can be a key factor of yield enhancement in higher multiplicity bins. This enhancement is independent of mass of a particle.

Λ* flows with pi, K, p up to $p_T = 3.5$ GeV/c, and the radial flow increases with increase of charge particle multiplicity in an event.

Hadronic scattering medium has negligible effect on its yield over charge particle multiplicity. This measurement may help models to have a upper bound of the hadronic scattering medium in p-Pb collisions at 5.02 TeV.

R.C. Baral, S. Sahoo and P. K. Sahu

Single Muon from Heavy Flavour Hadronic Decay:

The measurement of nuclear modification factor is important with event activities for heavy flavor. We will measure single muon from heavy flavor hadronic decay with muon stations at forward or backward rapidity depending on the orientation of Pb ions. High multiplicity events are much of interest for some of the observables indicating the formation of de-confined hadronic matter. R_{CP} is an observable which indicates the nuclear modification in central Pb to respect to the peripheral collisions. We are investing it for run-1 and run-2 for ALICE data.

M. M. Modal and P. K. Sahu

Ks/Lambda/Anti-Lambda/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.

P. K. Sahu and Collaborators

STAR collaboration:

Long-range correlation in rapidity in STAR Energies:

For small systems in pp or Pb, long-range correlation in rapidity, a ride like structure in dihadron correlations, is being observed in CMS and ALICE for high multiplicity events. The STAR experiment so far limited by rapidity coverage in doing such measurements. Forward Meson Spectrometer and central electromagnetic calorimeter in STAR has a wide coverage and it is suitable to such studies. pp, pAu and pAl at center of mass energy 200 GeV taken in 2015 is very relevant for study of ridge structure. The same study would help to understand the onset of gluon saturation, which is the pillar of CGC. The study involves us to study on $Delta_{eta}$-$Delta_{phi}$ correlation between FMS jets/photons/pi^0 and tracks/jet-clusters. It is quiet important to make a detailed study on jet clustering parameters so that we are enough sensitive to partonic level observables disentangling the effect of fragmentation which can potentially dilute the correlations.

S. Tripathy and P. K. Sahu

Production of D-mesons in *p*+*p* and *p*+Pb collisions at LHC energies:

D meson production cross-section in p-Pb collision at LHC energy plays a crucial role to distinguish the role of cold nuclear matter (CNM) effects from the effects of hot and dense matter produced in heavy ion collisions. CNM effects, such as shadowing effect, Cronin effect, etc., have been studied from the nuclear modification factor using different simulation models like HIJING and AMPT. Also, this nuclear modification factor has been evaluated from Next-to-Leading Order and Fixed-Order Next-to-leading Order calculations. We have published our investigation on nuclear modification factor of D mesons (D^0, D^+& D^{*+}) in p+Pb 5.02 TeV and compared with the ALICE results.

D meson correlation with charged hadron is sensitive to cold nuclear matter effect. K_T broadening effect of particles can predict correlation in azimuth angle, which can be used to infer effects like multi particle scattering and nuclear shadowing.

R.C.Baral, S.K.Tripathy, M.Younus and P.K.Sahu

Charmed Production at RHIC and ALICE Energies:

We are calculating strange and charmed hadron production at RHIC in U+U 193 GeV/nucleon collisions. Uranium nucleus is a deformed nucleus and thus its nuclear profile density has to be thoroughly examined before productions of any hadrons can be calculated. We are employing various phenomenological techniques to do the aforementioned work.

We are also calculating azimuthal anisotropy of charmed mesons for p+p and p+Pb collisions at LHC energies. Initial effects on the elliptic flow of the produced heavy mesons would be calculated. We aim to produce the results those would distinguish initial cold nuclear matter effects from hot QGP effects on particles' flow phenomena.

M.Younus and P. K. Sahu.

3.4 Experimental High Energy Physics

High Energy Physics is the study on the basic constituents of matter and their interactions. A large fraction of the energy in particle collisions is converted into particles flying away from the collision point in a fashion reminiscent of exploding fireworks. Most of the created particles have an ephemeral existence, decaying after a brief period of time into more stable ones. Detail studies on the properties of all known particles have revealed an inner order, which has been coded into a theoretical framework known as the Standard Model. Matter in all its forms, from stars to living organisms, can be described in terms of 12 fundamental particles, six quarks and six leptons, interacting among themselves by exchanging force particles - gluons, photons, or W and Z bosons - following strict mathematical rules based on symmetry principles. Experiments at the Intersecting Storage Rings at CERN were among the first to provide evidence for the existence of quarks through the measurement of high transverse momentum particle production. On the other hand experiments at the Brookhaven National Laboratory helped measuring the rate of neutrino-proton elastic scattering, an example of the neutral current interactions predicted by and essential to the foundation of the Standard Model. Further, experiments performed at the FermilabTevatron enabled the discovery of the top quark. We are currently looking forward to more discoveries at Fermilab and at the Large Hadron Collider at CERN.

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

High Energy Experimental Laboratory for ALICE and CBM:

Characterizations of GEM detector prototype:

Hardware:

A quadruple GEM detector prototype is built in IOP, HED lab and tested with Ar/CO2 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 a 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 Fe55 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 pico ammeter is used. The variation of Ion back flow fraction is observed with changing drift field, induction field as well as different GEM voltages.

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, P. K. Sahu, M. M. Mondal, D. S. Bhattachariya and S. Sahu

Design and fabrication of data logger to measure the ambient parameters in gas detector R&D:

A novel instrument has been developed to monitor and record the ambient parameters

such as temperature, atmospheric pressure and relative humidity. With this data logger continuous recording of temperature, atmospheric pressure, relative humidity and the time stamp can be done with a programmable sampling interval. The device is interfaced with computer by Lab-view software. This instrument

is very cheap and these parameters are very essential for understanding the characteristics such as gain of gas filled detectors like Gas Electron Multiplier (GEM) and Multi Wire Proportional Counter (MWPC). In this article the details of the design, fabrication and operation processes of the device has been presented.

S. Sahu, S. Swain, P. K. Sahu and S. Biswas

Nuclear astrophysics and nuclear equation of state: Radial modes of slowly rotating compact stars in presence of magnetic field:

Compact stars are composed of very high density hadron matter. When the matter abovenuclear matter density, then there is chance of different phases of matter such as hadron matter to quark matter. There is a possible phase which having a quark core surrounded by a mixed phase followed by hadronic matter, may be considered as hybrid phase inside the stars called hybrid star(HS). The star consists of only u, d and s quarks is called quark star (QS) and the star has only hadronic matter is called neutron star (NS). For the equation of state(EOS) of hadronic matter, we have considered Relativistic Mean Field (RMF) theory and we incorporated the effect of strong magnetic fields. For the EOS of quark phase we use the simple MIT bag model. We have assumed Gaussian parametrization to make the density dependent for both bag pressure in quark matter and magnetic field. We have constructedthe intermediate mixed phase by using Glendenning conjecture. Eigenfrequencies of radial pulsations of slowly rotating magnetized compact stars (NS, QS and HS) are calculated in a general relativistic formalism given by Chandrasekhar and Friedman. We have studied the effect of central density on square of the frequencies of the compact stars in the presence of zero and strong magnetic field.

N. R. Panda, K. Mohanta and P. K. Sahu

Search for the associated production of a Higgs boson with a top quark pair in final states with a tau lepton using the CMS detector at LHC

The ATLAS and CMS experiments at LHC had recently discovered a Higgs boson using the proton-proton (pp) collision data collected at a centre-of-mass energy of 7 and 8 TeV. The measured properties of the observed resonance are consistent with the expectations for the Standard Model (SM) Higgs boson within the uncertainties, corroborating the mechanism for electroweak symmetry breaking (EWSB) of the SM. However, it is important to measure its properties precisely in order to conclude that it

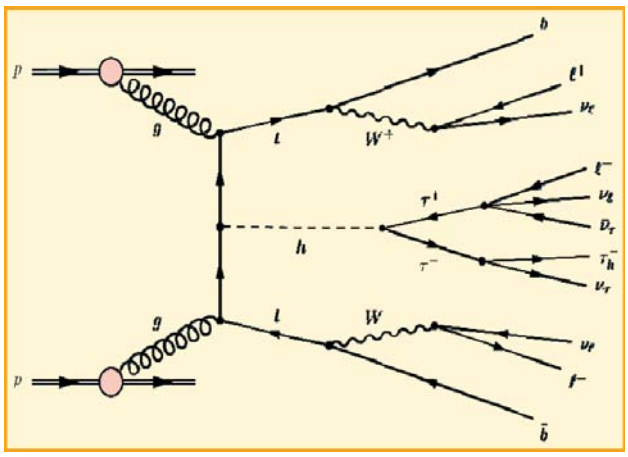


Fig. 1: *A typical Feynman diagram for* tt*(bar)*H *production with subsequent decay of the Higgs boson to a pair of tau leptons.*

is the SM Higgs boson. In 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. 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.

This analysis is performed to search for tt(bar)H production in final states with tau leptons in pp collision data corresponding to an integrated luminosity of 35.9 fb^{-1}, recorded by the CMS experiment in 2016 at a centre-of-mass energy of 13 TeV. A typical Feynman diagram for tt(bar)H production in this final state is shown in Fig.1. This analysis targets tt(bar)H final states with a reconstructed hadronic tau and is sensitive

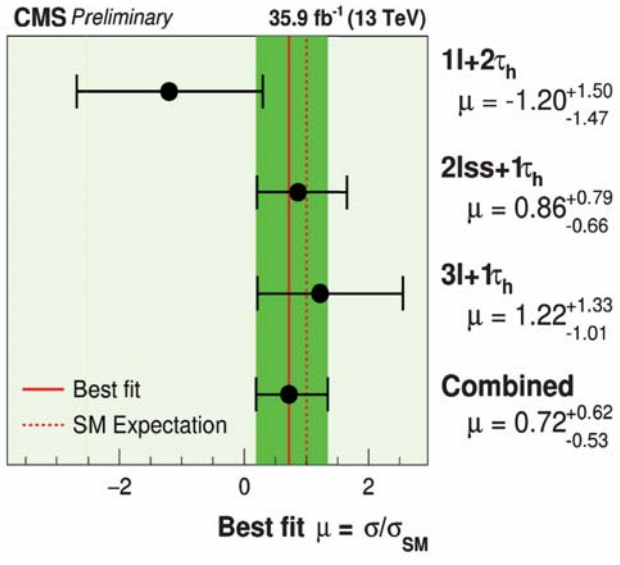


Fig. 2: *Signal rates m, in units of the SM tt(bar)H production rate, measured in each of the categories and for the combination of all categories.*

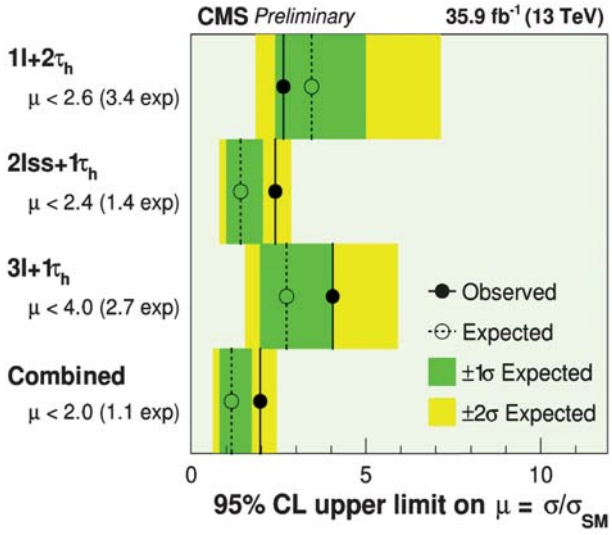


Fig. 3: *95% CL upper limits on the tt(bar)H signal rate, obtained in each of the categories and for the combination. The expected limits are computed for background-only (μ =0) hypothesis.*

to the H→τ τ decay mode. Three different final states are analyzed: (1) events containing two leptons (electrons or muons) of the same charge and one hadronically decaying tau lepton (τ_h), (2) events containing one lepton and two τ_h, and (3) events containing three lepton and one τ_h. 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 leading role in developing the BDT discriminant for this analysis. The signal contribution in each category is obtained by a maximum likelihood fit to the distribution of the above BDT or MEM discriminants. Signal rates mare computed for each of the categories individually and for their combination. The results are shown in Fig.2. The measured signal rates are compatible with SM expectation within the uncertainties. The upper limit on the signal

rate, computed at 95% CL, are also obtained, as shown in Fig 3. The observed limit computed for the combination of all three event categories amounts to 2.0 times the SM tt (bar) H production rate.

Reconstruction and identification of τ leptons in their decays to hadrons at CMS experiment

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 using the CMS detector 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, it 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 reduction in jet →τ_h mis-identification rate while retaining same τ_h efficiency as compared to the isolation sum discriminants, as shown in Fig. 1. The group played leading role in the overall coordination of the offline tau identification developments and is also playing major role in measuring the performance of the identification algorithms in proton-proton collision data recorded during 2016. The preliminary performance results have been already published in a detector performance note that shows the performance is data is compatible to the expectation from simulation. The analyses are ongoing for a full journal publication.

A. K. Nayak and Collaborators

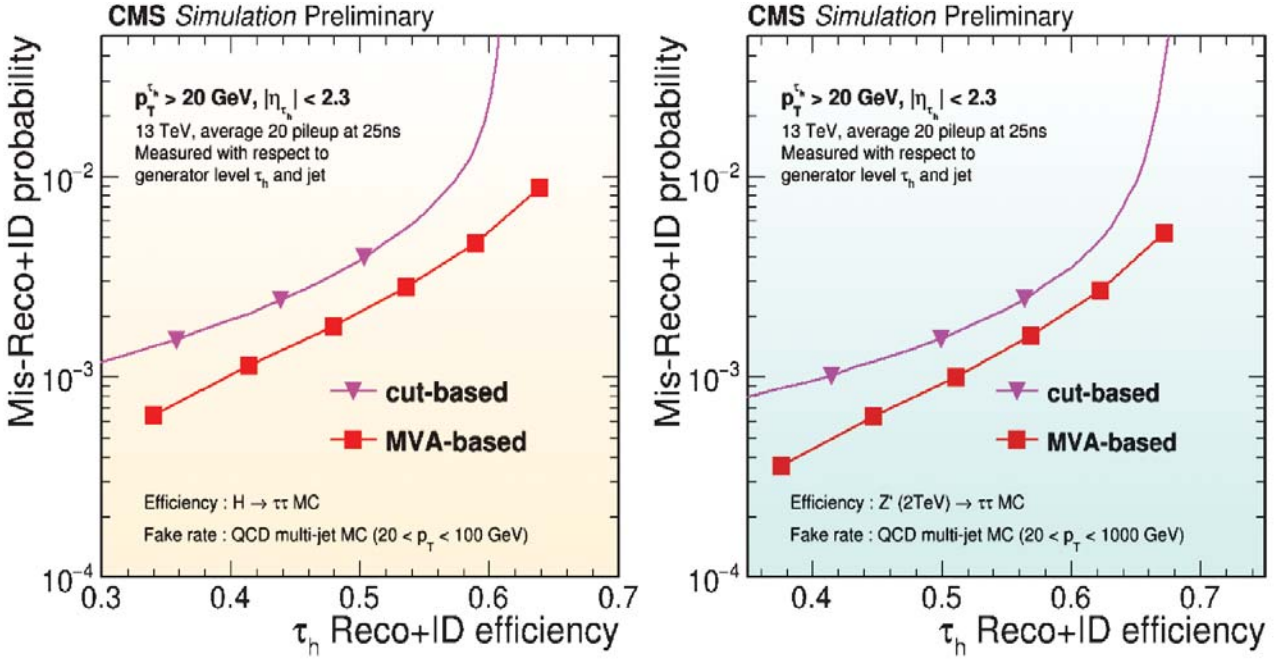


Fig. 1: Expected th reconstruction and identification efficiency against the jet →τ_h mis-identification probability for cut-based and MVA-based tau isolation discriminators.

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 transverse 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 from 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 2016 data, and so on. The performances of the jet and missing energy triggers in 2016 data are shown in Fig 1, which shows good efficiency for the online reconstruction of these objects with respect to the offline.

A. K. Nayak and Collaborators

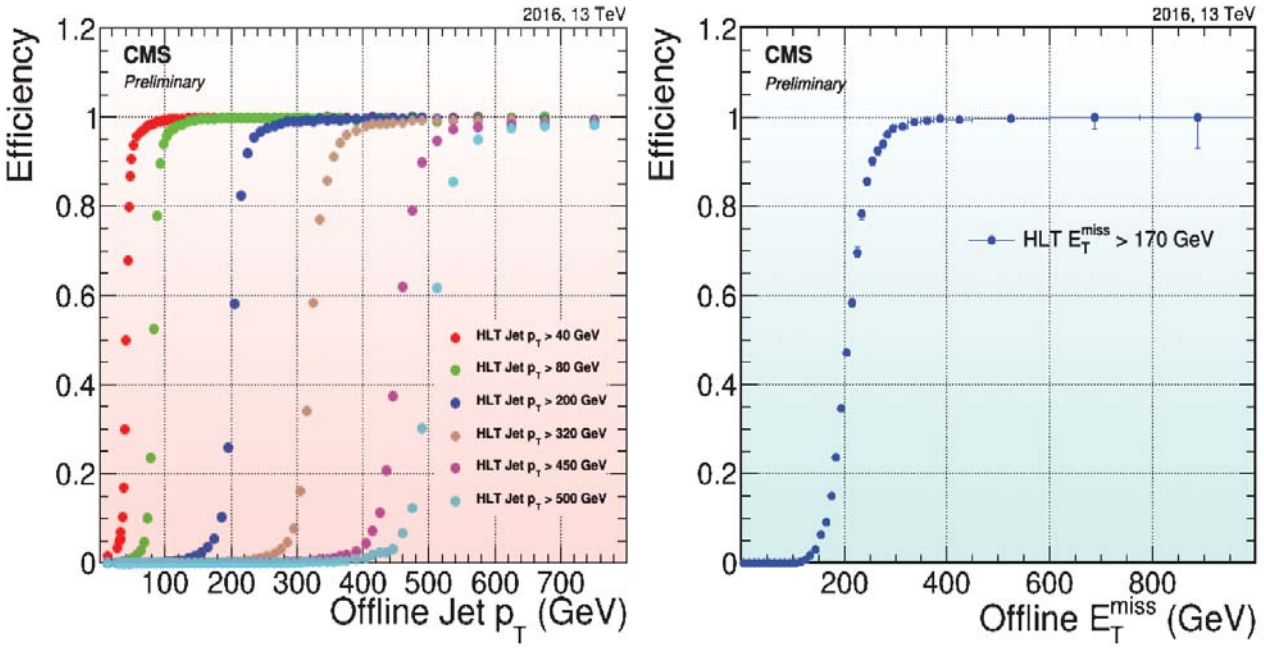


Fig. 1: The trigger efficiencies measured in data as a function of the offline reconstructed jet transverse momentum and missing transverse energy, respectively.

3.5 Quantum Information

Quantum information science is one of the frontier area of science and technology. It is also an interdisciplinary area of research where scientists from physics, mathematics, and computer science can contribute alike. One of the main goal is how well one can process information using laws of quantum theory. Quantum information theory aims to process information that is not amenable with classical devices. At the same time this also provides new insights into the nature of quantum world. Quantum information processing includes quantum computation, quantum communication, quantum cryptography and various information processing tasks. Not only this provides fundamental arena to investigate quantum phenomena but also gives new technological benefits like quantum teleportation, remote state preparation and secure communications.

(P. Agrawal)

The Hardy's nonlocality argument

Certain predictions of quantum theory are not compatible with the notion of local-realism.This was the content of Bell's famous 1964 Theorem. Bell proved this with the help of aninequality, famously known as Bell's inequality. The alternative proofs of Bell's theoremwithout using Bell's inequality are known as 'nonlocality without inequality (NLWI)' proofs.We review one such proof, namely the Hardy's proof which due to its simplicity and generalityhas been considered the best version of Bell's theorem.

P. Agrawal and Sujit K. Choudhary

Quantumness Vector: An Approach To Charactarise Quantumness of a Multiqubit Quantum state

In this work we discuss the notion of quantumness for a n-qubit system in two diûerent tracks.In the ûrst track we have taken the approach by which 'Quantum discord' have been deûnedand then extend the concept for a multiparty system by considering equivalent expressions ofn-variable mutual information which are same classically but diûer in the quantum domain.In the second track we redeûne quantumness vectors from the prespective of considering allpossible measurements. These approaches not only encompass measures of quantumness like discord but also give a uniûed view of the quantumness from the view point of projectivemeasurement done on the subsystem. We propose that quantumness of a multi-qubit stateis in principle are vectors and cannot be represented by a single quantity. These approachespave the way of visualizing quantumness from the aspect of vector quantities.

P. Agrawal and Sk. Sazim

New Bell inequalities for three-qubit pure states

We introduce a set of Bell inequalities for a three-qubit system. Each inequality within thisset is violated by all generalized GHZ states. More entangled a generalized GHZ state is, morewill be the violation. This establishes a relation between nonlocality and entanglement forthis class of states. Certain inequalities within this set are violated by pure biseparable states.We also provide numerical evidence that at least one of these Bell inequalities is violated bya pure genuinely entangled state. These Bell inequalities can distinguish between separable,biseparable and genuinely entangled pure three-qubit states. We also generalize this set ton-qubit systems and may be suitable to characterize the entanglement of n-qubit pure states.

P. Agrawal, Arpan Das and Chandan Datta

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 featureslike the mutual information for two random variables. Further, we deûne the conditionaluncertainty and show that conditioning on more observable reduces the uncertainty. Giventhree observables, we prove a 'strong sub-additivity' theorem for the conditional uncertaintyunder certain condition. As an application, we show that for pure product two-qubit states, the mutual uncertainty is bounded by 2 d2 = 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 mutualuncertainty for product, classical-classical, and classical-quantum state also takes a universalvalue 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 quantumtheory and quantum information using the mutual uncertainty, conditional uncertainty andthe strong sub-additivity for multiple observables.

P. Agrawal, S. K. Sazim, S. Adhikari and A. K. Pati

3.6 Experimental Condensed Matter Physics

Experimental condensed matter physics investigates the physical properties of ordinary matter around us in various forms: solids, liquids, engineered materials, and nanostructures. These systems have exhibited fascinating behavior which challenges our understanding of nature at a fundamental level. Physicists have invented many of the experimental tools used to probe the electronic, optical, magnetic, and vibrational properties of matter, and the development of increasingly sensitive measurement techniques continues on. Condensed matter physicists are also involved in the synthesis of artificially-structured materials, nanostructures, and nanoscale devices, which often manifest interesting behavior that is distinctly quantum mechanical in origin. Related emerging areas are Biophysics, which seeks to develop a physical basis of biological behavior, and Environmental Physics, which utilizes experimental techniques developed by physicists to address environmental concerns.

The Experimental Condensed Matter Physics Group at the UCR Department of Physics has active research programs in novel materials and nanostructures, highly-correlated electron physics, surface science, biophysics, precision measurement, linear and non-linear optics, muon-based spectroscopy, high-density positronium gases, spintronics, and molecular electronics.

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

Scaling Studies of Self-a fine Nanopatterned TiO_2 Surfaces created via Ion Implantation

Dynamic Scaling studies have been performed to investigate the morphological surface evolution of single crystal TiO_2(110) surfaces after they are implanted with Cobalt ions. These ion irradiated surfaces develop via non equilibrium growth processes and display rough interfaces with height ûuctuations that demonstrate self-afine behavior. The scaling exponents have been derived by applying height-height correlation as well as structure factor analysis techniques and show that diûusion plays a pivotal role in the evolution of these self-aûne surfaces.

S. Varma, Shalik R. Joshi, Anupama Chanda and D. Kanjilal

Investigating Hybrid ZnO nanosensor

Composite ZnO nanostructures have been prepared by electrodeposition technique, by including a small concentration of dopants. Sensing behavior of these hybrid nanostructures is being investigated. Results have been compared with the electrochemically deposited pure ZnO nanostructures. Composite nanostructures display much better sensing nature than the pure ZnO nanostructures. Sensitivity of the sensor has been investigated and it demonstrates a critical behavior.

S. Varma, A. Manna and S. Srivastava

Implantation of metallic ions in thin ûlms for investigating switching behavior

Metal oxide thin films have been irradiated by high energy metallic ions at IUAC Delhi. The modifications in the ûlms are being investigated by Raman spectroscopy and Atomic Force microscopy to understand their switching behavior. These studies are being carried out as a function of fiuence.

S. Varma, A. Manna, Aloke Kanjilal

Optical studies of Cobalt Implanted Rutile TiO_2 Surfaces

Photoabsorption properties of TiO_2 surfaces have been investigated after they have been implanted with low fiuences of Cobalt ions. The surfaces, after implantation, demonstrate fabrication of nanostructures and anisotropic nano ripple patterns. Creation of oxygen vacancies (Ti3+ states), development of cobalt nano-clusters as well as band gap modifications have also been observed. Results presented demonstrate that fabrication of self organized nanostructures, upon implantation, along with the development of oxygen vacancies and ligand ûeld transitions of cobalt ion promote the enhancement of photo-absorbance in both UV and visible regimes. These investigations on nanostructured TiO_2 surfaces can be important for photo- catalysis.

*S. Varma, Shalik R. Joshi, B.Padmanabhan, V.K. Malik, Anupama Chanda, N.C. Mishra and D. Kanjila*l

Constrained Nanostructures on Rutile TiO_2(110) Surfaces

Enhancement of absorption properties in constrained nanostructures of TiO_2, fabricated through the ion sputtering process, has been investigated. The nanostructures are anisotropic in nature, being elongated along [001] direction. The results indicate that the asymmetric diûusion

of mobile species, created by preferential sputtering, play crucial role in deûning the nanostructure morphology as well as their photo-absorption properties.

S. Varmar, V. Solanki, I. Mishra, Shalik R. Joshi, D. Kanjilal

Hydrothermal growth of aligned ZnO nanorods

Hydrothermal technique has been used to produce well aligned ZnO Nanorods (NRs). Raman studies, photo-absorption studies as well as FESEM investiga tions have been carried out. Quantum conûnement eûects lead to blue shift in the NR features in Raman spectroscopy. Enhanced photoabsorption properties indicate that this system can be utilized for photovoltaic applications.

S. Varma, P. Dash, A. Manna, P. K. Sahoo, N. C. Mishra

Unzipping of DNA via interactions with Nano-patterned SiO_2 Sur faces

Low energy ion irradiation has been utilized to create nano-patterns on the SiO_2 surfaces. The nano-patterned SiO2 surfaces were interacted with circular plasmid DNA. The Persistence length of the DNA is observed to reduce on the nano-patterned surfaces. DNA adsorption on SiO_2 surfaces indicates several types of chemical interactions as well as charge transfer. Furthermore, unzipping of DNA bases is also noticed. These results suggest severe modiûcations in the DNA moiety upon adsorption.

Indrani Mishra, S. Varma, Shalik Ram Joshi, S. Majumder, U Subudhi

Topological Insulators ARPES and DFT Band Mapping of BSTS

Discovery of the new quantum state of matter called topological insulators (TI) has attractedworld wide interest due to their exotic properties which are manifestations of a non-trivial and topology. TIs have insulating bulk and conducting edges due to the presence of some peculiar surface states (SSs). These SSs are spin non-degenerate with a unique property of spin momentum locking which results from the strong spin-orbit coupling (SOC) eûects in combination with time reversal symmetry. It has been theoretically predicted that these SSs host many interesting properties like, Dirac fermion, magnetic monopole and Majorana bound state at the vortex in superconducting regime. Strong immunity of these SSs to Anderson localization and backscattering in presence of non-magnetic impurities have tremendous technical advantages, especially for functional applications like spintronic devices and quantum computers. Furthermore, tunability of the crossing point of the topological SSs, called the Dirac point (DP) by chemical doping, is another aspect important from such technological point of view. In the known Bi and Sb based binary TIs the DP and the SSs are often obscured by contributions from bulk states. Tetradymite Bi_2Te_2Se which is isostructural to the prototypical TIs Bi2Se3 and Bi2Te3 has been found to be suitable for such tuning of the DP within the bulk band gap owing to its relatively large bulk resistivity. The resistivity can be optimized in the Sb doped quaternary alloy $Bi_{2x}S_{bx}Te_{3y}Se_y$ by changing the ratio of the pnictogen (Bi and Sb) and chalcogen (Se and Te) atoms without disturbing its

crystallinity. Thus, $Bi_{2x}Sb_xTe_{3y}Se_y$ provides an ideal platform to study the nature of topological surface states by tuning the Dirac node through controlling the proportion of chalcogen/ pnictogen atoms. Using angle resolved photoelectron spectroscopy (ARPES) and density functionaltheory we studied the quaternary topological insulator (TI) BiSbTe1.25Se1.75 (BSTS) conûrming the non-trivial topology of the surface state bands (SSBs) in this compound. We ûnd that the SSBs, which are are sensitive to the atomic composition of the terminating surface have a partial 3D character. Our detailed study of the band bending (BB) eûects shows that in BSTS the Dirac point (DP) shifts by more than two times compared to that in Bi_2Se_3 to reach the saturation. The stronger BB in BSTS could be due to the diûerence in screening of the surface charges. From momentum density curves (MDCs) of the ARPES data we obtained an energy dispersion relation showing the warping strength of the Fermi surface in BSTS to be intermediate between those found in Bi_2Se_3 and Bi_2Te_3 and also to be tunable by controlling the ratio of chalcogen/ pnictogen atoms. Our experiments also reveal that the nature of the BB eûects are highly sensitive to the exposure of the fresh surface to various gas species. These findings have important implications in the tuning of DP in TIs for technological applications.

H. Lohani, P. Mishra, A. Banerjee, K. Majhi, R. Ganesan, U. Manju, D. Topwal,P. S. Anil Kumar, & B. R. Sekhar

ARPES and DFT on a Week Toplogical Insulator

Bisumth based chalcogenides are exemplary strong three dimensional topological insulators that host an odd number of massless Dirac fermions on all surfaces. A departure from this notion is the idea of a weak topological insulator, wherein only certain surface terminations host surface states characterized always by an even number of Dirac nodes. Experimentally however, weak topological insulators have proven to be elusive. In collaborations with the Physics Department of IISc Bangalore we reported a weak topological insulator (WTI) BiSe which belongs from the Bi-chalcogenide family with a bulk energy gap of 50 meV. The structural unit consists of Bismuth bilayer (Bi2), a known quantum spin hall insulator stacked on either side with units of Bi2Se3 which are three dimensional topological insulators. Angle resolved photo-emission spectroscopy (ARPES) measurements on cleaved single crystals compared with DFT calculations conûrm a weak topological insulating phase in this material that deviates significantly from the relatively simple conventional notion of weak topological insulators being built out of stacked quantum spin hall insulators. Strikingly, the surface perpendicular to the growth direction, which also happens to be the preferred cleavage plane for BiSe is shown to host apair of overlapping Dirac cones.

Kunjalata Majhi1, Koushik Pal, Himanshu Lohani, Abhishek Banerjee, Pramita Mishra, Anil K. Yadav, R. Ganesan1, B. R. Sekhar, Umesh V. Waghmare, and P. S. Anil Kumar

ARPES and DFT Studies of BiPd a Superconducting Topological Insulator

An upsurge has been witnessed recently in the search for novel materials after realizing the signiûcant role of spin-orbit coupling (SOC)

eûects in the modification of near Fermi level (E_f) electronic structure of materials and thereby their physical properties. For example, presence of a strong SOC produces conducting edge states in topological insulators (TIs). Similarly, intertwining of the spin-orbit interaction with non-centrosymmetric (NCS) structures gives rise to some exotic phenomena of mixing up of spin-singlet and triplet Cooper pairing channels in superconductors (SCs). The anomalous value of upper critical ûeld (Hc_2), presence of Majorana surface states at the junction of superconducting transition temperature (T_c) and existence of Weyl fermion surface states in Weyl semimetals are a few more interesting properties related to the NCS structures behaving under SOC effects. These new class of materials not only present intriguing physics but also have tremendous scope in various applications. One of the interesting aspects of the NCS crystals is a broken inversion symmetry that gives rise to antisymmetric spin-orbit interaction (ASOC) which has been theoretically predicted to form an unconventional pairing in the NCS SCs. In our ARPES study of BiPd, we found that various bands are involved in the crossings of E_f along both the ΓX and Γ T directions. The FS depicts a high intensity distribution at various parts of the surface BZ resulting from various electron and hole like bands which are present in the vicinity of the Fermi energy. These results are consistent with the high metallic nature of BiPd observed in resistivity measurements. One hole pocket around the Γ point and an electron pocket around the X point are also identiûed from the near E_f ARPES intensity plots. The ARPES results show a fairly good agreement with the calculated band structure, mainly in the higher BE region, though the bands are nor very discernible as predicted in the calculations. Our orbital resolved DOS calculation reveals that the near E_f states are primarily composed of Bi-6p orbitals with a little admixture of Pd-4$d_{x^2-y^2/zy}$ while the states at higher BE (E b = 1 . 2 eV) are dominated by Pd-4d orbital character. This near E_f region is significantly modiûed with theinclusion of SOC eûects and various new hole and electron pockets arising from the spin-orbit split bands appear in comparison to the non-relativistic case. FS manifested by these bands consists of multi sheets of different dimensions, mainly three dimensions which disfavor the nesting conditions and weakens the possibility for any density wave instabilities in this system. Since, spin split bands in ASOC driven systems have different spin rotation restricting the spin-triplet pairing at specific parts of the FS, the pairing should mainly be of singlet nature mediated via phonons.

H. Lohani, P. Mishra, Anurag Gupta, V.P.S. Awana, B.R. Sekhar

Photoemission and DFT Studies of Superconductors

Discovery of superconductivity in Bi4O4S3 has brought the family of BiS2 based compounds to the focus owing to their similarities with the cuprates and Fe based superconductors in terms of quasi two dimensional layered structure. The BiS_2 compounds exhibit a layered structure composed of stacks of spacer layers and BiS2 layers. The BiS_2 layers have a strong bearing on many of the superconducting properties, similar to the case of the CuO layers in cuprates and Fe-P/Ch (P-pnictogen, Ch-chalcogen) layers in Fe

superconductors. Parent compounds of the BiS_2 family are weak insulators or semiconductors with band gap of 0.8 eV and superconductivity is induced by electron doping in the BiS_2 layers. The mechanism of superconductivity in these class of materials is still under intense debate as recent experimental and theoretical ûndings have led to diverse views. A group of researchers predicted the existence of a strong electron phonon interaction as a result of Fermi surface (FS) nesting, and thus proposed a s-wave superconductivity. The experimental results from magnetic penetration depth, muon spin rotation spectroscopy and ARPES also support a conventional s-wave BCS superconductivity mediated by electron phonon coupling. On the other hand, spin and orbital ûuctuations emerging from the FS nesting in combination with electron correlation, may lead to unconventional pairing symmetry. Further, the absence of any phonon anomaly in neutron scattering experiment, conform to a weaker electron phonon coupling against the theoretical predictions. ARPES measurements substantiated small Fermi pockets and an anomalous temperature dependence of the lowenergy spectral function indicative of a strong correlation- induced unconventional superconductivity. We investigated the electronic structure of SrFBiS2, $Sr_{0.5}La_{0.5}FBiS_2$ and $Sr_{0.5}Ce_{0.5}FBiS_2$ using valence band photoemission and LDA based band structure calculations. The spectral features shift towards higher binding energy, consistent with the electron doping, for the doped compounds. An enhanced metallicity in addition to the shift in the Fermi level towards the conduction band occurs for the Rare Earth (RE) doped compounds. Further, the degeneracy of bands along X-M direction at valence band maximum (VBM) and conduction band minimum (CBM) is lifted due to RE doping. An enhanced spectral weight near EF accompanied by a decrease in density of states at higher binding energy occurs for the doped compounds. This unusual spectral weight shift is substantiated by the change in Fermi surface topology and reduced distortion of Bi-S plane for the doped compounds (Physica C-2016) Recently discovered superconductors (SC) like Fe-pnictides, Fe-chalcogenides, SrRuO4 and organic SC, driven by unconventional pairing have given a new impetus to the research in the ûeld of superconductivity. Discovery of Pd based ternary chalcogenides, like $Nb_2Pd_{0.95}S_5$, Nb_2PdSe_5, Ta_2PdS_5, $Ta_2Pd_{0.97}S_6$, $Ta_2Pd_{0.97}Te_6$ and $Ta_4Pd_3Te_{16}$ is another advancement in this direction. These layered compounds provide a fertile ground for the existence of unconventional SC state owing to their Quasi-2-dimensional (Q2D) character. One of the most interesting compounds in this low dimensional family, is $Nb_2Pd_{0.95}S_5$. It exhibits a SC transition temperature (Tc) around 6 K and a high value of Sommerfeld constant (= 32 mJ/ mol K 2) which signiûes its strongly coupled SC nature. Resistivity of this compound shows a Fermi-liquid type behavior at low temperatures. Further, the heat capacity data is best ûtted by using a two band model which is a signature of multiband superconductivity. Theoretical studies of the electronic structure of some of these materials have been reported recently and established the multiband nature of these compounds. The Fermi surface (FS) of some of these compounds are composed of sheets of

electron-hole character of diûerent dimensions, which could favor the existence of various density wave instabilities, like charge density wave (CDW) and spin density wave (SDW) due to the nesting between the 1-D like sheets of FS in these systems. We have undertaken a comparative study of the valenceband electronic structure of Pd based ternary chalcogenide superconductors $Nb_2Pd_{0.95}S_5$, $Ta_2Pd_{0.97}S_6$ and $Ta_2Pd_{0.97}Te_6$ using experimental photoemission spectroscopy and density functional based theoretical calculations. We observe a qualitatively similarity between the valence band (VB) spectra of these compounds. Further, we find a pseudogap feature in at low temperature. We have correlated the structural geometry with the diûerences in VB spectra of these compounds. (Physica C-2016). We have also undertaken a comparative study of the VB electronic structure of $Nb_2Pd_{1.2}Se_5$ and $Nb_2Pd_{0.95}S_5$ in conjugation with DFT based calculations. We ûnd the VB spectra of both the compounds are qualitatively similar except for the slightly higher binding energy positions of features in $Nb_2Pd_{0.95}S_5$ relative to $Nb_2Pd_{1.2}Se_5$. The calculated DOS show that the VB features are composed mainly of Pd-Se/S hybridized states. The diûerent nature of DOS originating from the diûerently coordinated atoms signiûes an important role of the complex structural geometry in the electronic structure of these compounds. In addition, in our calculated DOS, states crossing the E_f are dominated by diûerent Pd-4d and Nb-4d orbitals ensuring a signiûcant role of multiband eûects in these compounds. Furthermore, $Nb_2Pd_{0.95}S_5$ spectra exhibits a depletion of spectral weight near the E_f with lowering the temperature to 77 K which is a signature of a pseudogap. This observation is consistent with a previous ûnding of sign reversal in Hall coeûcients below the temperature 100 K. Our comprehensive valence band electronic structure study in these compounds may open ways for further experimental and theoretical investigations in this field.

H. Lohani, P. Mishra, R. Goyal, V. P. S. Awana, and B. R. Sekhar

Ion beam radiation effects on natural halite crystals

Halites are one of the interesting material due to its color variations. Natural halites whose color ranges from transparent to dark blue were studied by UV–VIS and Raman spectroscopy. The halite crystals were irradiated with 3 MeV proton micro-beam (~20 µm beam width with ~80 PA beam current) for 10 and 90 min to study the radiation damage. After 10 mins of irradiation, small spot developed on the surface of transparent halite crystal whereas after 90 mins of irradiation the spot spread inside the bulk leading to a brown coloration (20 µm initial size to ~2.0 mm final size). The irradiated portion and the un-irradiated portion of the halites was characterized by Raman spectroscopic technique. The variation in the population density was observed from the UV–Vis spectra. The change in the Raman band intensities was observed for transparent, blue colored and proton beam irradiation halites. Such variation of spectroscopic characteristics due to proton irradiation suggests that the halite can be used for the radiation monitoring.

T. Arun. … P. V. Satyam

Ion beam induced endotaxial silver nanostructures in silicon

Coherently embedded structures in a crystalline substrate are known as endotaxial structures. In this paper, we report on the growth of silver (Ag) endotaxial structures in silicon using the aspects of both ion implantation and irradiation. In one case, endotaxial nanostructures of Ag at the Si interface are formed with 30 keV negatively charged silver ions (Ag") on GeO_x/SiO_x/Si system. In another case, 30 keV Ag" ions are used to create defects in GeO_x, SiO_x and in silicon substrate. Further deposition of a thin layer of Ag on irradiated GeO_x/SiO_x/Si system yielded endotaxial Ag nanostructures relatively at lower temperature (700 °C) compared to the system without any irradiation effects. We also reveal that the irradiation effects with 1.8 MeV Ag+ ions do not influence the early onset temperature of endotaxial nanostructure formation (unlike low energy ions). We show that it is essential to have crystalline silicon substrate to form Ag endotaxial nanostructures to grow endotaxial structures.

P. Guha,.., P. V. Satyam

Effect of Au thickness on AuAg bimetallic growth on reconstructed Si (5 5 12) surfaces

Large, stable and single domain unit cell with row-like structures makes reconstructed Si(5 5 12) surface an important one-dimensional growth template of nanostructures. We report on the morphological aspects of the growth of AuAg bimetallic nanostructures on a reconstructed Si (5 5 12) surface that has been deposited with a 0.5 monolayer (ML) Ag and various Au thicknesses (0.5 to 5.0 ML) to determine the optimum gold thickness for a growth of high aspect ratio of AuAg nanostructures. The mean aspect ratio of AuAg nanostructures increases up to Au thickness of 3.0 ML and for larger thickness the mean aspect ratio decreases. The prior growth of 0.5 ML Ag on reconstructed surface result in the formation of one-dimensional Ag strips which are helping for preferential nucleation sites along Si è'110é' to form AuAg bimetallic long aspect ratio structures. Followed by these early processes of growth, for Au thickness >3.0 ML, excess Au ad-atoms begin to accumulate along Si è'665é' and consequences reduction of mean aspect ratio of bimetallic nanostructures. Nanostructures are grown using molecular beam epitaxy method under ultra-high vacuum conditions and in situ scanning tunneling microscopy has been used to investigate the morphological variations. Determination of structural aspects and compositional analysis has been carried out using Rutherford backscattering spectrometry and high-resolution (scanning) transmission electron microscopy methods.

A. Bhukta … P. V. Satyam

Covalently Connected Carbon Nanotubes as Electro-catalysts for Hydrogen Evolution Reaction through Band Engineering (in collaboration with TIFR Hyderabad centre)

Controlled assembly of mesoscopic structures can bring interesting phenomena because of their interfaces. Here, carbon nanotubes (CNTs) are cross-coupled via a C–C bonding through Suzuki reaction resulting in three-dimensional (3D) CNT sponges, and these 3D CNTs are studied for their efficacy toward the electro-catalytic hydrogen evolution reaction

(HER) in acidic medium—one of the promising methods for the production of a renewable energy source, hydrogen. Both single and multiwall CNTs (SWCNTs and MWCNTs) are studied for the development of 3DSWCNTs and 3DMWCNTs, and these 3D CNTs are found to be HER active with small reaction onset potentials and low charge-transfer resistances unlike their uncoupled counterparts. First-principle density functional calculations show that the combination of electron acceptor and donor bonded to the CNT network can provide a unique band structure modulation in the system facilitating the HER reaction. This study can provide possibilities for band engineering of CNTs via functionalization and cross-coupling reactions.

S. Pal, … and T. N. Narayanan

Molecular dynamics simulation studies of gold nano-cluster on silicon (001) surface

Classical molecular dynamics simulations with modified embedded atom method model has been carried out to understand the interfacial behavior of a gold(Au) nano-cluster on a silicon(Si) surface. For illustration, a gold nano-cluster (NC) consisting of 108 atoms has been chosen on the Si (001) surface. We have investigated on the process of melting of this NC, the temperature dependent intermixing of Au and Si, and the diffusion of Au atoms into the Si substrate. It has been observed that the NC becomes semi-spherical around the room temperature and the melting process started around 450 K. In order to examine the substrate effect on the melting point temperature of the gold NC, a similar NC has been studied in vacuum. The melting point temperature of this free NC is found to be around 480 K. The observed suppression of melting temperature (by ~30 K) for the supported NC can be understood in terms of substrate induced change in morphology. We observe inter-diffusion between gold and silicon atoms for temperatures greater than 650 K.

S. S. Sarangi, et al.

Growth of Au capped GeO_2 nanowires for visible-light photodetection

A single step process to grow Au capped oxygen deficient GeO_2 crystalline nanowires via generation of growth species through the metal induced surface decomposition of Ge substrate is reported. Without the external source supply, the growth of the Au-GeO_2 nanowires on the Ge substrate is addressed with possible mechanism. Despite high band gap, application of GeO_2 as a possible new material for visible light photodetection is presented. The as-grown samples were found to have a photo-response of $\geq$ 102 with 17% external quantum efficiency at –2.0 V applied bias upon visible-light illumination (λ = 540 nm, 0.2 mW/cm2). This visible-light detection can be attributed to the oxygen vacancy related defect states as well as localized surface plasmon resonance induced absorption and subsequent hot electron injection from Au to conduction band of GeO_2. The photodetection performance of the devices has been understood by the proposed energy band diagrams. In addition, ≈4 times enhancement in the efficiency has been achieved by further decoration of the Au nanoparticles on the as-grown nanowire surfaces.

A. Ghosh, … P. V. Satyam…

Filled carbon nanotubes: 1D nano-magnets possessing uniaxial magnetization axis and reversal magnetization switching

The present study aims to control the direction of magnetization in Fe_3C, Co and Ni nanorods filled inside carbon nanotube (CNT). This control has been achieved during growth by modifying thermal chemical vapor deposition (CVD) system. As-grown in situ filled-CNTs were found to exhibit permanent magnetization. These CNTs have been characterized by using scanning electron microscopy (SEM), X-ray diffraction, Raman spectroscopy and transmission electron microscopy (TEM). Afterwards, direction of magnetization in Fe_3C, Co or Ni nanorod filled inside CNT has been further probed by using magnetic force microscopy (MFM). MFM measurements reveal that nanorod exhibits single domain behavior and direction of magnetization, instead of being controlled either by shape or magneto crystalline anisotropy, has been found to be influenced by magnetic field gradient, produced in modified thermal CVD system. Direction of magnetization has been found either along tube axis in vertical grown CNTs or in radial direction i.e. perpendicular to the tube axis in randomly grown CNTs. Besides investigated structural and magnetic properties, plausible growth model of in situ filling as well as mechanism to understand unique magnetization behavior has been proposed.

R. Kumari, …, P. K. Tyagi, and P. V. Satyam

Growth of large aspect ration AuAg bimetallic nanowires on Si (110) substrates

Large aspect ratio bimetallic nanowire structures comprise potential applications in areas such as higher catalytic activity and surface Raman enhancement spectroscopy (SERS) substrates. By using the highly anisotropic ultra-clean Si(110) surface and with initial growth of sub monolayer (ML) Ag on such surface, a high aspect ratio AuAg bimetallic nanostructures can be formed. We report on the formation of large aspect ratio ($> 7.2 \pm 0.8$) AuAg nanowires on ultra-clean Si (110) surfaces using 0.5 ML Ag followed by 3.0 ML Au using molecular beam epitaxy (MBE) at a growth temperature of 300 °C. Under similar growth conditions without pre-deposition of Ag and only with deposition of 3.0 ML of Au consequences smaller aspect ratio (2.1 ± 0.1) monometallic Au nanostructures. The enhancement in aspect ratio of the nanostructures is attributed to the formation of one dimensional Ag layer (prior to Au growth) and Au-Ag bimetallic intermixing at elevated temperature. Considering deposition of 3.0 ML Au, a regime of substrate temperature ≈ 270–330 °C is found to be optimum to growth some of high aspect ratio (>25.0) AuAg nanowires as well. Exterior of this regime, at lower temperature due to low mobility of the ad-atoms and at higher temperature due to probable inter-diffusion of Ag, such extremely high aspect ratio AuAg nanowires found to be infrequent to grow. For growth at substrate temperature 300 °C, mean aspect ratio of the AuAg nanostructures is gradually increased in accordance with Au thickness up to 3.0 ML due to preferential accumulation of ad-atoms (Au, Ag) along SiView the Math ML source and thereafter reduces for adequate accumulation along Si ⟨001⟩

A. Bhukta … and P.V. Satyam

Study of Ag induced bimetallic (Au-Ag) nanowires on Silicon (% 5 !2(surfaces: Experiment and Theoretical aspects

The reconstructed vicinal (high index) silicon surfaces, such as, Si (5 5 12) composes row-like structures that can be used as templates for growing aligned nanowires. By using a sub-monolayers of Ag, prior to Au deposition on reconstructed Si(5 5 12) surface, intermixing of Au and Ag, enhancement of aspect ratio of bimetallic AuAg nanowires with tunable morphology is reported. This is attributed to a combined effect of pre-grown Ag strips as nucleation centers for incoming Au ad-atoms and anisotropic Au-Ag intermixing. To achieve optimum conditions for the growth of larger aspect ratio AuAg nanostructures, the growth kinetics have been studied by varying growth and annealing temperatures. At H" 400°C, the Ag diffused into silicon substrate and the inter-diffusion found to inhibit the formation of AuAg bimetallic nanostructures. Controlled experiments under ultra-high vacuum condition in a molecular beam epitaxy system and in-situ scanning tunneling microscopy measurements along with ex-situ scanning transmission and secondary electron microscopy measurements have been carried out to understand the bimetallic nanostructure growth. Kinetic Monte Carlo (KMC) simulations based on kinematics of ad-atoms on an anisotropic template with a solid on solid model in which the relative ratios of binding energies (that are obtained from the Density Functional Theory) have been used and the KMC simulations results agree with the experimental observations. Advantage of having bimetallic structures as effective substrates for Surface enhanced Raman spectroscopy application is demonstrated by detecting Rhodamine 6G (R6G) molecule at the concentration of 10^{-7} M.

A. Bhukta, …, and P. V. Satyam

Surface protection coating material for controlling the decay of major constructin stone

Degradation of the building stones are creating instability in the old building and monuments which is to be protected. To investigate the characteristics of such a stones used for the construction in eastern India, we have collected the khondalite stones. The microstructural and elemental composition analysis of the khondalite stones are analyzed by using SEM, EDX and PIXE trace elemental analysis. We have prepared surface protection coating material with graphene oxide and cobalt ferrite as a base material along with other residuals. The prepared coating materials is coated on the galvanized iron substrate for further characterization. The surface morphology characteristics of the coating material is analyzed by SEM and AFM. The corrosion resistance characteristics of the prepared coating material is studied by the electrochemical impedance spectroscopy. The results suggests that the prepared coating material can be used as a surface protection materials to control the self-destruction of khondalite stones.

T. Arun, …., and P. V. Satyam

Ag nanoparticles decorated Molybdenum oxide structures: Growth, characterization, DFT studies and their application for enhanced field emission

We report a simple single step growth of α-MoO_3 structures and energetically suitable site

specific Ag nanoparticles (NPs) decorated α-MoO_3 structures on varied substrates, having almost similar morphologies and oxygen vacancies. We have elucidated possible growth mechanism in the light of experimental findings and density functional theoretical (DFT) calculations. We have experimentally established and verified by DFT calculations that MoO_3(010) surface as weakly interacting and stable surface compared to other orientations. From DFT study, the binding energy is found to be higher for (100) and (001) surfaces (≈ – 0.98 eV), compared to (010) surface (–0.15 eV) and it is likely that Ag NPs formation is not favorable on MoO_3(010) surface. Ag decorated MoO_3 (Ag-MoO_3) nanostructured sample shows enhanced field emission (FE) properties with ≈ 2.1 times lower turn-on voltage of 1.67 V/μm and one order higher field enhancement factor (β) of 8.6×104 compared to MoO_3 sample without Ag incorporation. From Kelvin probe force microscopy (KPFM) measurements, the average local work function (Φ) is found to be ≈ 0.47 eV smaller for Ag-MoO_3 sample (≈ 5.70±0.05 eV) compared to MoO_3 sample (≈ 6.17±0.05 eV) and the reduction in Φ can be attributed to the shifting Fermi level of MoO_3 toward vacuum via electrons injection from Ag.

P. Guha, …, P. V. Satyam

Real Time In-situ Synchrotron X-ray Diffraction Study of Endotaxial Silver Nanostructures Growth: Effect of Temperature on Thermal Expansion Coefficient

We report on the real time crystalline growth of coherently embedded (endotaxial) silver nanostructures (NSs) in modified single crystal silicon substrates (having additional deposition of GeOx on native oxide of Si) using a simple hot stage as a chemical vapour deposition (CVD) chamber in ambient condition at a synchrotron X-ray diffraction (XRD) beam line. We study the growth process of crystalline silver NSs in two cases: (a) silver vapors (generated by heating silver wire on hot stage) onto GeOx/SiOx/Si substrate and (b) pre-deposited ≈ 2 nm silver thin film on GeOx/SiOx/Si substrates. As the temperature is raised from room temperature to 850 °C, the evolution of various diffraction peaks, such as, (111), (200) and (220), reflecting from growth facets of Ag NSs are monitored. We observe the ordered Ag NSs with the same crystallographic orientation as substrate surface at the temperature ≥ 800 °C for both the cases. By measuring the deviation of Ag lattice parameter due to shift in diffraction peak positions as a function of temperature, thermal expansion coefficients (TECs) for Ag NSs in a matrix and their relation to the corresponding crystallite sizes (CSs) have been determined. TEC is found to decrease while the corresponding CS is increasing. Activation energy (E0) of silver NSs is found to be 0.171 ± 0.004 eV, in which Ag wire has been used as source and 0.247 ± 0.009 eV, where Ag film has been deposited for insitu XRD measurements.

P. Guha, …, P. V. Satyam

Ion beam induced surface nanostructuring of semiconductors and their applications

Ion-beam induced surface nanostructuring of semiconductors

We are working on synthesis of self-organized nanostructures on semiconductor

surfaces by using low-to-medium energy (0.2-100 keV) ions and trying to understand the underlying physical mechanisms in terms of various experimental parameters and the existing theories. In our recent papers, we have shown that both sputter erosion and ion-beam induced prompt atomic redistribution are responsible for ripple formation on Si, Ge, and SiO_2 surfaces at medium ion energies. Interestingly, usage of Au ions leads to fascinating ordering in the long nanowire-like patterns created on Ge surfaces. 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 specially chosen experimental parameters. Further, under concurrent substrate rotation, one creates mounds/dots on Si surface instead of ripples which are otherwise set to form if there would be no rotation. Likewise, low energy Ar-ions lead to nanowire-like pattern formation on GaAs surfaces at elevated temperatures. As a matter of fact, different types of patterned surfaces are being fabricated and used by us for potential applications, viz. solar cells, spintronics, optoelectronics, plasmonics, etc. where we use them as templates for deposition of thin films.

S.A. Mollick, M. Saini, M. Sk, S. K. Garg, T. Basu, S. P. Patel, D. P. Datta, and Tapobrata Som

Tailoring optoelectronic properties of oxide thin films grown on patterned silicon templates

Low energy ion-beam fabricated nanofaceted Si substrates with various heights and widths show good anti-reflection property. An ion fluence-dependent anti-reflection (AR) performance is observed from these nanofaceted silicon surfaces. These nanofacets are successfully used by us for deposition of different oxide thin films. For instance, we have shown the efficacy of Al-doped zinc oxide (AZO) and Zn-doped tin oxide overlayers on ion-beam synthesized nanofaceted silicon for suppressing reflection loss. In addition, we have studied in detail the electric transport properties of these oxide overlayers and compared the same with those grown on pristine-Si substrates.

We have also carried out a large number of experiments on AZO and ZTO films grown on rippled- and faceted-Si substrates and observed surface morphology-driven anisotropy in their optoelectronic properties. Through these studies we are in the process of evaluating the possible improvements in AR property as well as reduction in electron-hole recombination towards using them as active layers in oxide-based solar cells.

M. Saini, M. Sk, T. Basu, R. Singh, M. Kumar, and Tapobrata Som

Tailoring plasmonic properties of silver nanostructures grown on patterned silicon templates

Low energy ion-beam fabricated nanorippled Si substrates have anisotropic topographical nature which are being used as templates to grow silver nanoparticle s to tune their plasmonic property. In this case, we are growing commercially available liquid-suspended Ag nanoparticles (of different dimensions) on rippled-Si substrates fabricated under different ion energies. Spectroscopic ellipsometry in conjunction with UV-Vis spectroscopic measurements show size (of Ag nanoparticles)- and wavelength (of Si ripples)-

dependent shift in the Ag plasmonic peak. The results are compared with the Ag nanostructures grown on pristine-Si substrates as well. As a next step, we plan to grow Ag nanoparticles on pristine- and rippled-Si substrates using molecular beam epitaxy (MBE) under ultra-high vacuum condition.

M. Saini, A. Mitra, and Tapobrata Som

Magnetic anisotropy in Co thin films on rippled substrates of Si and Ge

In-plane magnetic anisotropy in Co thin films, of varying thicknesses, grown on rippled-Si and -Ge substrates are investigated. Thin films were deposited at different oblique angles of incidence by RF magnetron sputtering technique. The results are compared with the films deposited on pristine-Si and Ge substrates as well. Co films grow conformally on rippled substrates and show a strong uniaxial magnetic anisotropy with the easy axis of magnetization parallel to the ripple directions. Antiferromagnetic exchange coupling has also been observed when magnetic field is applied perpendicular to the ripple direction.

S.A. Mollick, R. Singh, T. Basu, M. Kumar, S. P. Patel, B. Satpati, and Tapobrata Som

Growth and characterization of thin films for photovoltaics and resistive switching applications

Oxide thin films using DC/RF magnetron sputtering and pulsed laser deposition techniques

We are studying growth of transparent conducting oxide (TCO) thin films, viz. In_2O_3:SnO_2 (ITO), ZnO:Al_2O_3 (AZO), and ZnO:SnO_2 (ZTO) on glass and silicon substrates. The main objective is to study three-dimensional columnar growth of these materials by glancing angle deposition technique. It is observed that room temperature (RT) grown ITO, ZTO, MoO_3, and AZO thin films, deposited by RF and pulsed DC sputtering, show high transmittance and low resistance. All these films are utilized as active layers in oxide-based solar cells.

We are also working on resistive switching for which we regularly grow different oxide thin films like ZnO:Cu, Cu_2O, TiO_2, and MoO_3 using magnetron sputtering and pulsed laser deposition.

R. Singh, A. Dutta, D. Hasina, M. Saini, M. Kumar, B. Satpati, and Tapobrata Som

Local probe electrical transport property of aluminum-doped zinc oxide thin films

We demonstrate a polarization-mediated tunable nanoscale charge transport in Al-doped ZnO (AZO) thin film using conductive atomic force microscopy. In fact, we show that charge transport across an AZO film can be tuned by applying an external nano-Newton force, which confirms the presence of polarization in the film. In addition, we also demonstrate the role of polarization on the inhomogeneous work function using Kelvin probe force microscopy. The observed experimental result is attributed to defect-induced polarization in AZO film and will be a step forward to fabricate mechanical force tunable diode.

We also demonstrate that the work function of Al-doped ZnO (AZO) 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. These findings are 1further confirmed by calculations based on first-principles theory. Tuning the work function of AZO 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 devices.

M. Kumar, S. Mookerjee,and Tapobrata Som

Hole-blocking property of TiO_2 thin films

We investigate the hole-blocking properties of a TiO_2 layer when a heterostructure is grown on a chemically textured *p*-Si substrate. X-ray diffraction data reveal the amorphous nature of as-grown TiO_2 thin films which undergoes a transition to a crystalline one after annealing. In addition, bulk current-voltage characteristics show that the leakage current increases after annealing which corroborates well with a change in the band gap due to a transition from amorphous to crystalline (anatase phase) TiO_2. Moreover, TiO_2/Si heterojunction allows the transport of electrons but blocks the transport of holes. These results are compared with those obtained for TiO2 films grown on pristine-Si substrates. The present findings are not only important for the fundamental understanding of the charge transport across the TiO_2/Si heterostructure but also to design hole-blocking solar cells. Recently, we have also started working on other hole and/or electron selective layers like MoO_3, WO_3, and $BiFeO_3$ for similar applications.

R. Singh, M. Saini, M. Kumar, B. Satpati, A. Singh, and Tapobrata Som

Resistive switching behavior in Copper-doped Zinc Oxide and Copper Oxide thin films

We have grown Cu-doped ZnO thin films on Si by pulsed laser deposition (PLD) technique. The films are found to be smooth and uniform over reasonably large surface areas and demonstrate bipolar 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.

We have also shown multimode resistive switching in copper oxide nanostructures using conductive atomic force microscopy. Multimode resistive switching is observed in consecutive operation cycles from all around the sample. The different modes are interpreted in the framework of a thermally induced defects. The model implies that the optimization of the conductive filament active region is crucial for the future application of nanoscale resistive switching devices.

M. Saini, M. Kumar, R. Singh, B. Satpati, A. Mitra, and Tapobrata Som

Fabrication of textured semiconductor surfaces for photovoltaic applications

Chemically textured Si with improved absorption in the complete range of solar spectrum is investigated by ultraviolet/visible/near-infrared (UV/Vis/NIR) spectroscopy, showing an average specular reflectance of ~0.4% in the wavelength of 500–3000 nm. The pyramidal structures on such solar-blind Si can reduce the reflectance further <0.1% in the UV region by

conformal growth of granular Al-doped ZnO (AZO) films. Likewise, we have also demonstrated the efficacy of pyramidally textured Si surfaces as templates to grow Cu_2O, MoO_3, TiO_2, and other oxide materials (using DC/RF sputtering) towards achieving highly anti-reflecting surfaces for developing oxide-based solar cells.

Following the above studies, we have started making textured surfaces of other semiconductors like Ge, GaAs, and InP where the above-mentioned oxide layers will be integrated for applications in photovoltaic cells.

R. Singh, M. Kumar, A. Dutta, M. Sk, S. A. Mollick, B. Satpati, and Tapobrata Som

Ion implantation induced modification of semiconductors Nanofabrication/modification by ion-beams

Tandem *p–n* junctions have been synthesized in ZnO nanorods by implanting 50 and 350 keV O^+-ions at room temperature. Conducting-AFM measurements reveal the formation of Schottky-like junctions between AFM tip and NRs. Photoluminescence measurements demonstrate the recovery of near band edge (NBE) emission upon annealing, while an additional dominant deep level emission is also observed. De-convolution analysis shows that these peaks originate from oxygen interstitials and may contribute to p-type conductivity in ZnO NRs. Such implanted NRs, may be suitable for green emissions and *p*-type conductivity.

A. Singh, V. Siva, D. P. Datta, and Tapobrata Som

Ion-beam modification of thin films

In our studies, ion irradiation is used to induce significant modification in electrical, optical, and structural properties of oxide thin films grown on different semiconductor substrates, viz. Si, Ge, GaAs, and InP. In addition, defect induced resistive switching is expected to take place in thin films of TiO_2 and MoO_3 followed by tunability in optical band gap, work function, and hole-blocking properties. For this purpose, low energy novel gas ions (few keV - tens of keV) are bombarded on the films at room temperature to yield controlled defect formation.

R. Singh, D. Hasina, S.A. Mollick, and Tapobrata Som

Giant magnetocaloric effect in $GdAlO_3$ and $GdMnO_3$

Of late scientific and engineering efforts are directed towards magnetic refrigeration technology due to its high-energy efficiency and eco-friendly characteristics over conventional gas compression/expansion cooling technology. The feasibility for producing magnetic refrigerator for commercial use was established in 1997 with the observation of giant magneto caloric effect (18.8 $J.Kg{\cdot}K^{-1}$) in $Gd_5Si_2Ge_2$. We investigated magnetic properties and magnetocaloric effect of polycrystalline $GdAlO_3$ and $GdMnO_3$ to assess their potential usage as magnetic refrigerants at cryogenic temperatures. These compounds undergo antiferromagnetic transitions at low temperatures which is associated with giant magnetic entropy change effect ($-\Delta SM$) ~ 40.9 J/Kg.K under a field change of 0-9 T for GdAlO3 while moderate effect of 18 J/Kg.K is observed for polycrystalline GdMnO3. Though the relative cooling power of both the stated materials is

similar however, absence of magnetic and thermal hysteresis makes GdAlO3 a more efficient magnetic refrigerant than GdMnO3 .

$CH_3NH_3PbI_3$ - A potential solar cell candidate: Structural and Spectroscopic investigations

We investigated the structural, electronic and optical properties of one of the promising solar cell materials, organometallic lead halide perovskite- $CH_3NH_3PbI_3$. Temperature dependent crystallographic phase transitions in the system was studied using X-ray diffraction and detailed Rietveld refinements and correlated with the observed heat capacity observations. Also, the refinement parameters point to the presence of a centrosymmetric space group in all the three phases viz. orthorhombic, tetragonal and cubic phases. Valence band photoemission measurements show the band edge to be around 1.40 eV and optical studies reveals a band gap of 1.62 eV at room temperature. We have extracted information regarding the exciton binding energies as well as exciton-phonon interactions from the temperature dependent photo luminescence studies and the exciton binding energy and optical phonon energy of CH3NH3PbI3 are found to be 57.59 meV and 33.18 meV, respectively. Our present study offer valuable perception into the band diagram of such important organic inorganic hybrid perovskite, encouraging further research and applications in solar cell devices.

Thermoelectric properties of ternary half-Heuslar LuPdBi

We report the experimental study of low temperature thermoelectric properties of ternary half-Heuslar LuPdBi, synthesized by conventional arc melting. Resistivity measurements reveal the semi metallic nature of the conduction behavior, where holes are the major charge carriers as confirmed from positive value Seebeck coefficient in the entire temperature range 18–350 K. Thermal conductivity behavior indicates that the dominance phonon contribution and bipolaronic effects at low temperature regime with negligible electronic contribution. A considerably high power factor (~ 100 $\mu W/mK^2$) is obtained at room temperature.

Complex Magnetic behavior in $GdCrO_3$

Magnetic behavior of Gadolinium orthochromites ($GdCrO_3$) was successfully explained by complex 3*d*-4*f* magnetic coupling. The nearest neighbor symmetric and antisymmetric exchange coupling in Cr-sublattice is found to be J_e = 11.058 K and D = 2.64 K from modified Curie-Weiss law modeled by Moriya. Positive Zeeman energy between the net moments and the applied field drives spin flipping of Cr and Gd-sublattices in cooling cycle, which leads to distinct magnetization behavior in cooling and heating cycle. Spin reorientation sets in at low temperature (T_{SR} 45 K) and with external magnetic field (MF) it shifts towards low temperature and disappears at around 2000 Oe.

Ferrielectricity in the metal-organic ferroelectric tris-sarcosine calcium chloride

Ferroelectrics (FEs) and antiferroelectrics (AFEs) are well known among low-symmetry crystals and are directly analogous to ferromagnets and antiferromagnets, with polarization *P* replacing magnetization *M*. However, ferrielectrics (FIs), with approximately

antiparallel dipole ordering but net polarizations and with a switchable component are very rare, except among liquid crystals. Tris-sarcosine calcium chloride (TSCC) has a reported second-order displacive paraelectric (PE) to FE phase transition near *T*c=130K. The main aim of this work is to show that the FE phase of TSCC is actually a textbook paradigm of ferrielectricity. A secondary point of broad interest is that it has the highest figure of merit for electrocaloric materials, according to the new model by Guzmán-Verri and Littlewood.Tris-sarcosine calcium chloride has an unusual (perhaps unique) structure with four polarizations per unit cell in both its PE and FE phase, permitting ferrielectricity without change in primitive cell size, e.g. three polarizations up and one down. Thus, this paper provides what may become a standard textbook example of ferrielectricity.

Our study shows a paradigm of ferrielectricity in a single-phase crystal, tris-sarcosine calcium chloride [TSCC; (CH3NHCH2COOH)3CaCl2]. Ferrielectricity is well known in smectic liquid crystals but almost unknown in true crystalline solids. C. F. Pulvari [Ferrielectricity, Phys. Rev. **120**, 1670 (1960)] reported it in 1960 in mixtures of ferroelectrics and antiferroelectrics (AFEs), but only at high fields. Tris-sarcosine calcium chloride exhibits a second-order displacive phase transition near *T*c=130K that can be lowered to a quantum critical point at 0 K via Br or I substitution and phases previously predicted to be AFE at high pressure and low temperatures. Unusually, the size of the primitive unit cell does not increase in the so-called AFE phase. We measure hysteresis loops and polarization below *T*=64K and provide clear Raman evidence for this paraelectric-ferrielectric transition. We use Raman spectroscopy to show that the primitive unit cell does not double at low temperatures or high pressures, and hence that the structures are not AFE in the usual sense. These spectra also establish that the low-*T* and high-pressure phases are not the same.

S. Sahoo and collaboration.

Molecular beam epitaxy of three-dimensional Dirac oxide material

These days have witnessed a surge of attention in solid state research to explore and investigate materials that exhibit band topology dependent exciting electronic properties. Furthermore, several theoretical studies have been proposed involving artificial layered structures that induce novel topological states. Experimentally, these predictions have not been tested yet, largely owing to difficulties in growing epitaxial thin films. Thin films of topological materials are the useful building blocks because more exotic states maybe produced with external perturbation easily. High-quality single-crystalline thin films of topological materials have so far been limited to relatively simple binary compounds although efforts towards creating more complicated materials continue. Moreover, the volume of the work so far on topological phases is limited to materials belonging to group IV-VI elements that have extended *s* and *p*-type derived orbitals at the Fermi-level. Recently, a series of anti-perovskites including Sr_3PbO are predicted to host three-dimensional Dirac electrons and have also topological crystalline insulator characteristics. We fabricated an anti-perovskite thin film, Sr_3PbO, grown by MBE on $LaAlO_3$. The successful growth of high quality

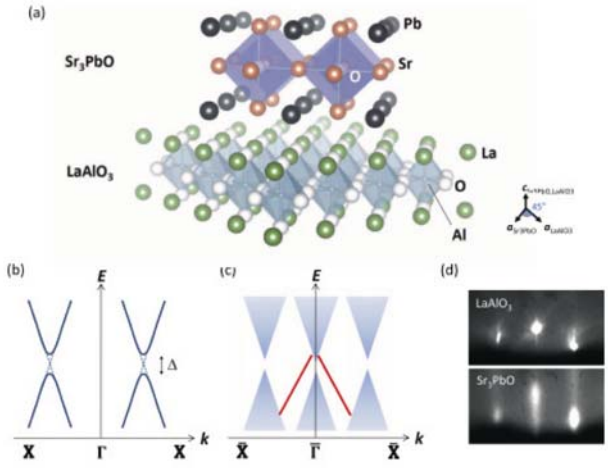


Figure: *Crystal structures of anti-perovskite Sr_3PbO on $LaAlO_3$. For Sr_3PbO, an oxygen ion (white) is surrounded by six Sr ions (orange) to form an octahedron (semi-transparent blue). (b) Schematic electronic band diagram for bulk Sr3PbO along X-Γ-X momentum line. Δ indicates a small mass gap (~10 meV) occurring at Dirac points. (c) Schematic band diagram for (001) surface of Sr3PbO. Red lines show topological surface states, and blue shaded region represents surface projection of bulk bands. (d) RHEED images before (top) and after (bottom) the growth of Sr3PbO taken with the beam in the [100] direction of $LaAlO_3$*

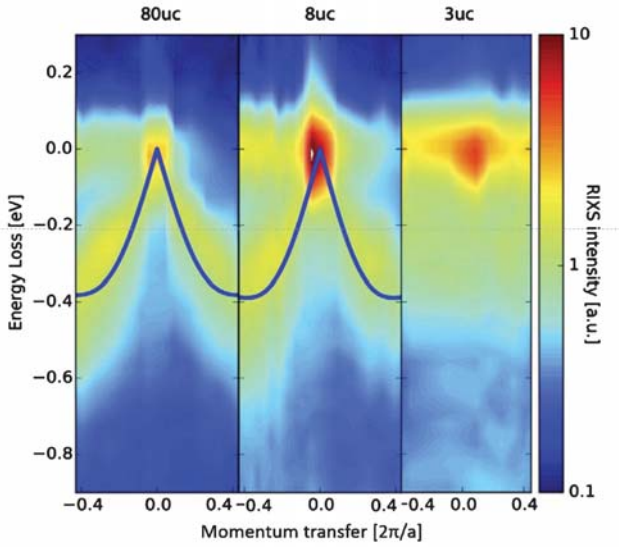
Sr_3PbO film and the preliminary investigation on its electronic properties is an important step for the exploration of its unique topological properties and also widens the scope of materials to realize unconventional topological phases *via* artificial heterostructures.

D. Samal, H. Nakamura, and H. Takagi

Quenched magnon excitations by oxygen sub-lattice reconstruction in ultrathin $SrCuO_2$thin film

Despite the great focus high-T_c cuprates have received in the last three decades, a comprehensive explanation for superconductivity is still lacking. Since conventional BCS-like phonon mediation has been ruled out, it has been widely accepted that magnetic fluctuations play a significant role. However, their role is still controversial in light of the discovery of competing charge-ordering phenomena. Therefore, huge effort has recently been put in the investigation of the interplay between structural modifications and magnetic excitations. It is thus desirable to investigate the impact of structural changes on the microscopic magnetism of cuprates. Complex oxide thin films and heterostructures in particular provide a multitude of possibilities to manipulate electronic/lattice degrees of freedom in a controlled way at the atomic scale that leads to emergent phenomena. The broken and/or modified symmetry, charge transfer, electrostatic coupling, strain, frustration, and the two-dimensionality of electronic structure produce many novel effects and functions that cannot be attained in the parent bulk constituents.

Infinite layer $SrCuO_2$ undergoes a structural transformation from bulk planar to a quasi-one-dimensional conformation by re-arranging the



oxygen sub-lattice below a critical thickness of about 5 unit cells due to its polar nature. The effect

of chemical doping on the magnetic excitations in the cuprates has been studied intensively. However, studies on collective magnetism by structural modifications, while leaving the stoichiometry intact, are missing so far. Here, we report on direct measurements of the influence of a structural reconstruction on collective magnetic excitations in cuprate 2D layers. We observe no coherent magnetic excitations for 3 unit cell (uc) case (quasi-one-dimensional), however a clear signature of antiferromagnetic magnetic excitation spectrum is revealed for the thick films having bulk like planar structures.This study allows us to compare the dimensionality-induced defect scattering to the known effects of chemical doping in cuprates. Further, this study emphasizes the ability of ultrathin films and superlattices to act as an easily modifiable model system of 2-dimensional layered cuprates.

Contour plots of the RIXS data for the 80 uc thick film, 8 uc superlattice, and 3 uc superlattice. The solid lines in case of 80 uc and 8 uc samples are the fits to linear spin wave theory No coherent magnetic excitations for 3 uc case is observed.

D. Samal and Collaborators

Suppressed upper critical field in a Superconducting / Ferromagnetic bilayer

Singlet superconducting and ferromagnetic order are antagonistic to each other and generally they do not coexist in bulk materials. However, the fabrication of thin film heterostructures using thin film deposition techniques has made it possible to investigate the interplay between superconductivity and ferromagnetism in close proximity. The control over layer thickness provides an added opportunity to change the

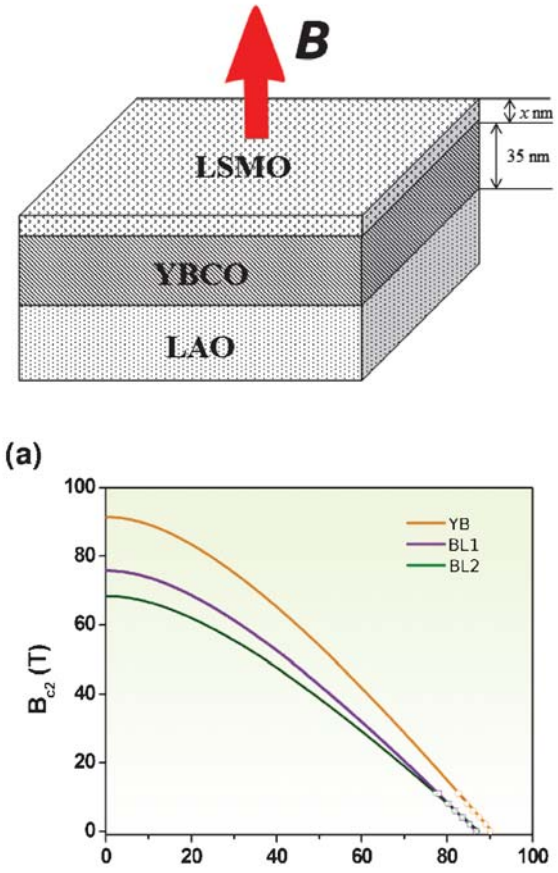


Figure: *Schematic of the superconducting (YBCO)/ ferromagnetic (LSMO) bilayer layer YBCO, bilayer BL1 and bilayer BL2 respectively. B -T phase diagrams for YBCO (YB) and bilayers (BL1, BL2) constructed from magneto-transport data using WHH formalism.with varying LSMO thickness grown on $LaAlO_3$ (LAO). x= 0,16 and 28 for single.*

relative strength of competing order parameters by varying the layer thickness. The mutual interaction between the two competing order parameters at the superconductor/ ferromagnet (SC/FM) interface gives rise to a variety of novel electronic phenomena and has led to a wide study of such systems over last few decades.

We have investigated the influence of ferromagnetic $La_{0.7}Sr_{0.3}MnO_3$ (LSMO) layer on the upper critical field (B_{c2}) of $YBa_2Cu_3O_{7-\delta}$ (YBCO) in YBCO/LSMO bilayer. The upper critical field

is estimated from magnetotransport data using WHH and GL formalism. We find that the upper critical of YBCO in YBCO/LSMO bilayer gets suppressed by a few tens of Tesla as compared to the single YBCO layer. Moreover, we also observe that the extent of suppression of Bc2 increases with increasing LSMO layer thickness. We have provided a comprehensive discussion to account for the suppression based on spin polarized quasiparticle injection induced cooper-pair breaking ,magnetic proximity effects and finally local magnetic field emanating from the ferromagnetic LSMO layer, which increases with the increasing LSMO layer thickness.

A Gaurav, B R Sekhar, P S Anil Kumar and D Samal

Manipulating the superconducting properties by atomic layer engineering

Realisation of high-T_c superconductivity in atomically enginneered heterostructures provides a unique platform to manipulate its behavior in a controlled way and understand the underlying complex structure-property relationships. Despite the fact that a fundamental understanding of the mechanism for high-T_c superconductivity in cuprates remains elusive, experimental data from the view point of crystal structure reveals that the underlying crystal-lattice structure plays a key role. In a simple picture, the structural model of high-T_c cuprate superconductors is built on a *natural superlattice*, where the current carrying CuO_2 planes are interleaved with the charge-reservoir blocking/ balance layers. *What if we mimic layered superconductors by using atomic-scale LEGO blocks? The assembly using atomically thin layers with some intelligently guessed differences seems worth a try, especially when the mechanism of high-T_C superconductivity remains unknown!* Such an approach tends to be more flexible and can possibly harbour high-T_c superconductivity without resorting to any chemical substitution leading to uncontrolled disorder. In this project, we conceive, design, and demonstrate a model infinite-layer based cuprate hybrid that hosts superconductivity by manipulating the sub-layer characteristics at unit cell level and subsequently elucidate the possible mechanism. Indeed, our investigation unfolds the possibility to realize high-$T_c$superconductivity in a designed hybrid structure that entangles two IL-based cuprate blocks {$Sr_{0.6}Ca_{0.4}CuO_2$ (SCCO) and $BaCuO_2$ (BCO)} having different attributes in terms of their oxygen sublattice structure and atomic polarisability.

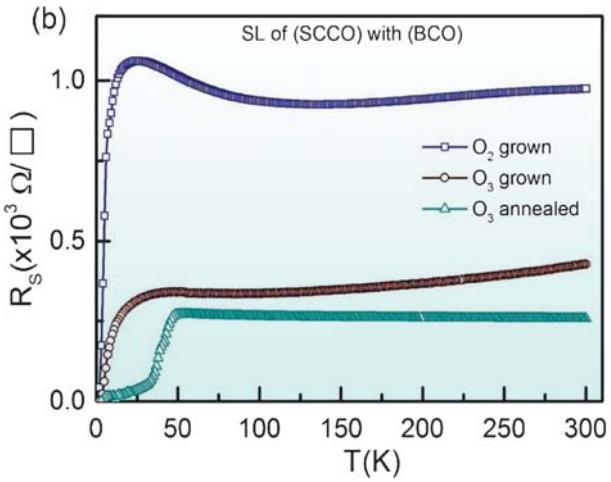


Figure: *Temperature-dependent sheet resistance for SCCO/ BCO superlattices under various condition.*

D. Samal and Collaborators

Band Gap Modulation in SnO_2 Microstructures by Pb Doping

The electronic band gap is an intrinsic character of a semiconductor and it governs the

underlying electronic and optical properties. Tin oxide (SnO_2) is widely known as a direct wideband gap (3.6 eV) semiconductor crystallizing in rutile tetragonal structure. Due to its optical transparency in the visible range, high electrical conductivity, and long term stability, it is deemed to have potential application in optoelectronic devices including solar cells, flat panel displays and touch screen sensors.Despite all its alluring properties, the large band gap of SnO_2 limits its useful application. Therefore, it is

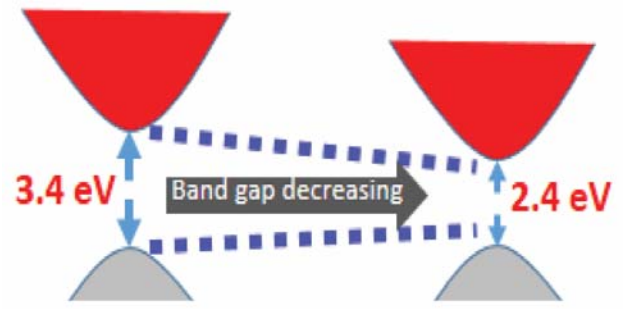


Figure: A schematic representation for band gap decrease in Pb doped SnO_2 microstructure.

imperative to engineer the band gap in SnO_2 to a lower value. The electronic band gap in semiconductors can dramatically be influenced by cationic substitution/chemical doping, strain engineering, applying external pressure and lattice disorder. A recent first principles study by Ma *et al.* (*ACS Appl. Mater. Interfaces,* **2016**, 8 (39), 25667) on rutile SnO_2 interestingly found that it can be tuned into a moderate gap semiconductor and then a normal semimetal and finally a band inverted semimetal with tensile strain. Indeed, they showed a substantial narrowing of the band gap in SnO_2 by Pb-doping. Pb is isoelectronic to Sn, but with a larger atomic size, and therefore results in the increase of unit cell volume. Here we experimentally corroborate this possibility on microstructured thin films of Pb-doped SnO_2. We show a reduction in band gap by approximately 1 eV upon 10 % Pb doping from optical absorption study. The observed tunability of band gap in SnO_2 with Pb-incorporation provides an efficient approach to harness its utility-potential. Further studies are required to understand the charge transport behavior such as mobility, electron effective mass and type of charge carriers in Pb-doped SnO_2 samples. Moreover an extensive work is in progress to map out the Pb-concentration dependent band gap modulation with various doping level in SnO_2.

S. N. Sarangi and D. Samal

Tailoring d-electron based heavy fermionic systems by superlattice design

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 are 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 originating from the Coulomb interaction between electrons become more prominent and complex. Moreover, both thermal and quantum fluctuations are largely enhanced with a reduction in dimensionality, thereby expanding the critical regions for phase transition to occur. Thus, many body effects that do not exist in three dimensions are expected to prevail in low-dimensional systems. Indeed, two-dimensional systems exhibit exciting properties such as high-T_c superconductivity in cuprates and iron pnictides and metallic conduction in transparent oxides. If heavy fermionic systems can be made 2D, even more fascinating ground states are expected to result, and thus such studies are very much desirable. Our goal is to fabricate $CaCu_3Ru_4O$ or related heavy-fermionic based superlattices to study the low dimensional effect and then explore the possibility of artificially producing proximity induced heavy-fermionic superconductivity.

D. Samal, S. N. Sarangi and Collaborators

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Sudipta Mahana and D. Topwal;

App. Phys. Lett. 110, 102907 (2017)

111. Ion irradiation induced phase transition of Co in Co/Au multilayers

Vantari Siva, Siddharth S. Sahu, D. P. Datta, P.C. Pradhan, M. Nayak, V. Solanki, D. Topwal, Kartik Senapati, Pratap K. Sahoo;

Journal of Alloys and Compounds 680 (2016) 722

112. Expansion of a Discrete [3 × 3] Mn9 Metallogrid to a μ-Carboxylato-Bridged Polymeric {Mn11}n Assembly

Avinash Lakma, Sayed Muktar Hossain, Rabindra Nath Pradhan, Dinesh Topwal, Andrea Cornia, and Akhilesh Kumar Singh;

Eur. J. Inorg. Chem. 2016 (2016) 2993

113. Ferrielectricity in the metal-organic ferroelectric tris-sarcosine calcium chloride

J. F. Scott, F. D. Morrison, Alexandra, M. Z. Slawin, Rebecca Clulow, Aurora S. A. Gherson, Alice M. Bumstead, Jonathan Gardner, Silvia C. Capelli, Michael R. Probert, Satyaprakash Sahoo, J. S. Young, R. S. Katiyar, E. K. H. Salje;

Phys. Rev. B 95, 094119 (2017).

114. Molecular beam epitaxy of topological crystalline insulator Sr_3PbO,

D. Samal, H. Nakamura, and H. Takagi;

APL Mater. 4, 076101 (2016)

115. Quenched magnon excitations by oxygen sub-lattice reconstruction in (SrCuO2)n/(SrTiO3)2 superlattices,

M. Dantz, J. Pelliciari, D. Samal, V. Bisogni, Y. Huang, P. Olalde-Velasco,V. N. Strocov, G. Koster, and T. Schmitt;

Sci. Rep. 6, 32896 (2016)

116. **Synthesis of Cu doped Zn Onanorods for photosensitive UV detection application**,
S. N. Sarangi, V. Siva, B. K. Padhi and P. K. Sahoo;
Advanced Materials Letters,8, 524, (2017).

117. **Controllable growth of Zn Onanorods via electrodeposition technique: towards UV photo detection**,
S. N. Sarangi;
J. Phys. D: Appl. Phys.49 (35), 355103 (2016).

4.2 Papers Communicated / Submitted to International Refereed Journals

1. **Bubble-bound state of triplestranded DNA: Effmov Physics in DNA with repulsion,**
Jaya Maji, F. Seno, A. Trovato and S. M. Bhattacharjee, arXiv:1703.09432

2. **What is dimension?**
S. M. Bhattacharjee arXiv:1611.03048

3. **Use of Topology in physical problems,**
S. M. Bhattacharjee arXiv:1606.04070

4. **Tunneling Conductance in Normal-Insulator-Superconductor junctions of Silicene**,
Surajit Sarkar, Arijit Saha, Suhas Gangadharaiah; *arXiv: 1609.00693 [cond-mat]*

5. **Thermoelectricpropertiesofaferromagnet-superconductorhybridjunction: Role of interfacial Rashba spin-orbit interaction**,
Paramita Dutta, Arijit Saha, A. M. Jayannavar; arXiv: 1611.00353 [cond-mat]

6. **Emerging trends in Topological Insulator and Topological Superconductor**,
Arijit Saha, A. M. Jayannavar; arXiv: 1611.04252 [cond-mat]

7. **Study of Brownian functionals in physically motivated models with purely time dependent drift and diffusion,**
Asutosh Dubey, Malay Bandyopadhyay and A. M. Jayannavar; Manuscript to be submitted to Phys. Rev. E.

8. **Extracting Work from a single heat bath using velocity dependent feedback**
Arnab Saha, Rahul Marathe and A. M. Jayannavar; To be submitted to Phys. Rev. E.

9. **Single Particle Brownian Heat Engine With Microadiabaticity**,
Arnab Saha and A. M. Jayannavar; To be submitted to Phys. Rev. E

10. **Two coupled classical Ising spin systems working as an engine,**
Debarshi Basu, Joydip Nandi, A. M. Jayannavar and Rahul Marathe; Submitted to Phys. Rev. E.

11. **Using a Szilard engine to illustrate the validity of the modified Jarzynski equality in presence of measurement errors,**
Sourabh Lahiri and A. M. Jayannavar; Manuscript to be submitted.

12. **Universal fluctuations in orbital diamagnetism: A surprise in theoretical physics,**
P. S. Pal, Arnab Saha and A. M. Jayannavar; arXiv:1609.01603.

13. **Extracting Work from a single heat bath using open-loop protocol,**
Arnab Saha, Rahul Marathe and A. M. Jayannavar; arXiv:1609.03459 Submitted to Phys. Rev. E.

14. **Study of Brownian functionals in physically motivated model with purely time dependent drift and diffusion,**
Ashutosh Dubey, Malay Bandyopadhyay and A. M. Jayannavar; arXiv:1609.04302 Submitted to Phys. Rev. E.

15. **Fluctuation Theorems of work and entropy in Hamiltonian systems,**
Sourabh Lahiri and A. M. Jayannavar; arXiv:1611.00949 Resonance (in press).

16. **Second law, Landauer's Principle and Autonomous information machine,**
Shubhashis Rana and A. M. Jayannavar; arXiv:1611.01993 Resonance (in press).

17. **Emerging trends in Topological Insulator and Topological Superconductor,**
Arijit Saha and A. M. Jayannavar; arXiv:1611.04252 Resonance (in press).

18. **Transport coherence in a time-asymmetric rocked ratchet model,**
Mamata Sahoo and A. M. Jayannavar; arXiv:1612.04446 Submitted to Phys. Rev. E.

19. **Control of Decoherence in different environments : A case studyfor dissipative magneto-oscillator,**
Asam Rajesh, Malay Bandyopadhyay and A. M. Jayannavar; arXiv:1612.04626, Submitted to Phys. Rev. E.

20. **How long does a quantum particle or wave stay in given region of space?**
S. Anantha Ramakrishna and A. M. Jayannavar; arXiv:1612.05709 Resonance (in press).

21. **Role of partition in work extraction from multi-particle Szilard Engine,**
P. S. Pal and A. M. Jayannavar; arXiv:1612.07007 Submitted to Phys. Rev. E.

22. **Barrierless reaction kinetics : Inertial effect on different distribution functions of relevant Brownian functionals,**
Ashutosh Dubey, Malay Bandyopadhyay and A. M. Jayannavar ;
arXiv:1701.03335Submitted to Phys. Rev. E.

23. **Interacting Multi-particle Classical Szilard Engine,**
P. S. Pal and A. M. Jayannavar ; arXiv:1701.07188

24. **Thermal transport in a ferromaganet-superconductor hybrid junction:effects due to interfacial spin-orbit interactions,**
Paramita Dutta, Arijit Saha and A. M. Jayannavar; Submitted to Phys. Rev. B.

25. **Non-locality in quantum first passage times,**
Abhishek Dhar, Sourabh Lahiri and A. M. Jayannavar, Work in progress.

26. **Memory erasure in non-equilibrium systems: beating the Landauer limit,**
S. Lahiri, A. Kundu and A. M. Jayannavar; Submitted to Phys. Rev. E.

27. **Landauer bound for erasure using non-ideal gas**,
P. S. Pal and A. M. Jayannavar arXiv:1703.04872.

28. **Control of Decoherence in different environments : A case study for dissipative magneto-oscillator,**
Asam Rajesh, Malay Bandyopadhyay and A. M. Jayannavar; Submitted to JPB.

29. **Thermodynamic functions in the case of a charged particle coupled to a heat bath in non-Abelian gauge potentials,**
Asam Rajesh, Malay Bandyopadhyay and A. M. Jayannavar

30. **Rotational diffusion under torque: Microscopic reversibility and excess entropy**
Bandopadhyay, S., Chaudhuri, D., & Jayannavar, A. M. (2016).. Preprint arXiv.1602.05008

31. **Rotational Brownian motion: Trajectory, reversibility and stochastic entropy**,
Swarnali Bandopadhyay, Debasish Chaudhuri, A. M. Jayannavar (accepted for publication in the Journal of Statistical Physics).

32. **Towards laboratory detection of topological vortices in superûuid phases of QCD**,
Arpan Das, Shreyansh S. Dave, Somnath De, and Ajit M. Srivastava,
arXiv:1607.00480, submitted to Phys. Lett. B.

33. **Eûects of magnetic ûeld on the plasma evolution in relativistic heavyion collisions**,
Arpan Das, Shreyansh S. Dave, P. S. Saumia, Ajit M. Srivastava,
arXiv:1703.08162, submitted to Phys. Rev. C

34. **Quantum mutual information and quantumness vectors for multi-qubit systems**,
Sk. Sazim and Pankaj Agrawal;
arXiv preprint arXiv:1607.05155.

35. **New Bell inequalities for three-qubit pure states**,
Arpan Das, Chandan Datta and Pankaj Agrawal;
arXiv preprint arXiv:1611.09916.

36. **Mutual Uncertainty, Conditional Uncertainty and Strong Sub-Additivity**,
Sk. Sazim, Satyabrata Adhikari, Arun Pati and Pankaj Agrawal;
arXiv preprint arXiv:1702.07576.

37. **Structural and electronic phase evolution of Tin dioxide,**
Sudipta Mahana, Pitamber Sapkota, Saptarshi Ghosh, U. Manju, D. Topwal;
arxiv:1606:08137 (2016)

38. **Band Structure of Topological Insulator BiSbTeSe2**
H. Lohani, P. Mishra, A. Banerjee, M. Unnikrishnan, D. Topwal, P. S. Anil Kumar and B. R. Sekhar;
Scientfic Reports (Nature Publication Group)(2017).

39. **Indirect searches of Galactic diffuse dark matter in INO-MagICAL detector ,**
Amina Khatun, Ranjan Laha, Sanjib Kumar Agarwalla; Submitted in Journal of High Energy Physics (JHEP) e-Print arXiv:1703.10221 [hep-ph]

40. **New parameterization of the effective field theory motivated relativistic mean field model,**
Bharat Kumar, S. K. Singh, B. K. Agrawal, S. K. Patra (communicated to Phys. Lett. B).

41. **Fission yield of neutron-rich thermally fissile nuclei within statistical model,**
Bharat Kumar, M.T. Senthilkannan, M. Balasubramaniam, B. K. Agrawal, S. K. Patra (communicated to Phys. Rev. C).

42. **Astrophysical S-factor of some (p-ã) reactions,**
K. C. Naik, R. N. Panda, A. Quddus, S. Ahmad, Bharat Kumar and S. K. Patra, Communicated to J. Phys. G.

43. **The attribute of rotational proûle to the hyperon puzzle in the prediction of heaviest compact star,**
M. Bhuyan, S. K. Patra and Shan-Guia Zhou, (Communicated to J. Phys. G).

44. **Structure effects on fission yields,**
Bharat Kumar, M. T. Senthilkannan, M. Balasubramaniam, B. K. Agrawal and S K Patra (Communicated to Phys. Lett. B).

45. **Ternary fission within the temperature dependent relativistic mean field approach,**
M. T. Senthilkannan, Bharat Kumar, M. Balasubramaniam, B. K. Agrawal and S . K. Patra (Communicated to Phys. Rev. C).

46. **Evidence of a proton halo in 23Al: A mean field analysis,**
R. N. Panda, Mamina Panigrahi, Mahesh K. Sharma and S. K. Patra (communicated for publication).

47. **Effect of Deformation on Structure and Reaction of Al Isotopes using Relativistic Mean Field Densities in Glauber Model,**
Mamina Panigrahi, R. N. Panda and S. K. Patra (Communicated to Indian Journal of Physics).

48. **Coherent diffractive photoproduction of rho0 mesons on gold nuclei at RHIC**
(L. Adamczyk…. P K. Sahu… et al.). Submitted Mar. 1, 2017 (e-Print Archives (1702.07705)

49. **Measurements of jet quenching with semi-inclusive hadron+jet distributions in Au+Au collisions at 200 GeV**
(L. Adamczyk…. P K. Sahu… et al.). Submitted Feb. 2, 2017 (e-Print Archives (1702.01108)

50. Harmonic decomposition of three-particle azimuthal correlations at RHIC
(L. Adamczyk…. P K. Sahu… et al.).Submitted Jan. 24, 2017 (e-Print Archives (1701.06496)

51. Bulk Properties of the Medium Produced in Relativistic Heavy-Ion Collisions from the Beam Energy Scan Program(
(L. Adamczyk…. P K. Sahu… et al.). Submitted Jan. 24, 2017(e-Print Archives (1701.07065)

52. Constraining the initial conditions and temperature dependent transport with three-particle correlations in Au+Au collisions
(L. Adamczyk…. P K. Sahu… et al.).Submitted Jan. 23, 2017 (e-Print Archives (1701.06497)

53. Measurement of D0 azimuthal anisotropy at mid-rapidity in Au+Au collisions at 200 GeV
(L. Adamczyk…. P K. Sahu… et al.)(Submitted Jan. 23, 2017 (e-Print Archives (1701.06060)

54. Global Lambda hyperon polarization in nuclear collisions: evidence for the most vortical fluid
(L. Adamczyk…. P K. Sahu… et al.)(Submitted Jan. 21, 2017 (e-Print Archives (1701.06657)

55. Measurement of the cross section and longitudinal double-spin asymmetry for di-jet production in polarized pp collisions at 200 GeV
(L. Adamczyk…. P K. Sahu… et al.)Submitted Oct. 24, 2016 , published Nov. 30, 1999 (Phys. Rev. D 95 (2017) 71103(e-Print Archives (1610.06616)

56. Di-Jet Imbalance Measurements at 200~GeV at STAR
(L. Adamczyk…. P K. Sahu… et al.).Submitted Sep. 15, 2016 (e-Print Archives (1609.03878

57. Upsilon production in U+U collisions at 193 GeV with the STAR experiment
(L. Adamczyk…. P K. Sahu… et al.).(Submitted Aug. 24, 2016 , published Dec. 15, 2016 (Phys. Rev. C 94 (2016) 64904(e-Print Archives (1608.06487)

58. Charge-dependent directed flow in Cu+Au collisions at 200 GeV(
(L. Adamczyk…. P K. Sahu… et al.). Submitted Aug. 13, 2016 , published Jan. 5, 2017 (Phys. Rev. Lett. 118 (2017) 12301(e-Print Archives (1608.04100)

59. Energy dependence of J/psi production in Au+Au collisions at 39, 62.4 and 200 GeV
(L. Adamczyk…. P K. Sahu… et al.). (Submitted Jul. 26, 2016 (e-Print Archives (1607.07517)

60. Direct virtual photon production in Au+Au collisions at 200GeV
(L. Adamczyk…. P. K. Sahu… et al.).(Submitted Jul. 6, 2016 e-Print Archives (1607.01447)

61. Filled carbon nanotubes: 1D nano-magnets possessing uniaxial magnetization axis and reversal magnetization switching,
R. Kumari, A. Singh, B. S., Yadav, D. R. Mahapatra, A Ghosh, P. Guha, P. V. Satyam, M. K. Singh, P. K. Tyagi, Submitted to Carbon (2017)(under review)

62. Growth of large aspect rationAuAg bimetallic nanowires on Si (110) substrates,
Bhukta, P. Guha, B. Satpati, P. Maiti, P. V. Satyam Appl. Surf. Sci. (Submited, under review)

63. **Study of Ag induced bimetallic (Au-Ag) nanowires on Silicon (% 5 !2(surfaces: Experiment and Theoretical aspects,**

Bhukta, T. Bagarti, P. Guha, R. Sathyavathi, B. Satpati, B. Rakshit and P. V. Satyam Surface Science (Submitted, under review: 2017)

64. **Surface protection coating material for controlling the decay of major constructin stone,**

T. Arun, D. K. Ray, V. P. Gupta, S. S. Panda, P. K. Sahoo, J. Ghosh, P. Sengupta, AIP Conference Proceedings (2017, submitted)

65. **Ag nanoparticles decorated Molybdenum oxide structures: Growth, characterization, DFT studies and their application for enhanced field emission**

P. Guha, A. Ghosh, R. Thapa, E. M. Kumar, S. Kirishwaran, R. Singh and P. V. Satyam; Nanotechnology (2017, under review)

66. **Real time In-situ synchrotron X-ray Diffraction Study of Endotaxial silver nanostructures growth: effect of temperature on thermal expansion coefficient,**

P. Guha, R. R. Juluri, A. Bhukta, A. Ghosh, S. Maiti, A. Bhattacharya, V. Srihari and P. V. Satyam; Crystal Engineering Communication (2017, under review)

67. **Synthesis of *p–n* junctions in ZnOnanorods by O^+ ion implantation**

Avanendra Singh, K. Senapati, D. P. Datta, R. Singh, Tapobrata Som, S. Bhunia, D. Kanjilal, and P. K. Sahoo;

Nucl. Instr. Meth. Phys. Res. B (In press).

68. **Aspects of ions induced texture evolution on Ge surface: A statistical assessment**

S. K. Garg, D. P. Datta, D. Kanjilal, and Tapobrata Som**;**

Nucl. Instr. Meth. Phys. Res. B (In press).

69. **Glancing angle deposition of SiO_2 thin films using a novel collimated magnetron sputtering technique**

S. M. Haque, K. Divakar Rao, S. Tripathi, R. De, D. D. Shinde, J. S. Misal, C. Prathap, Mohit Kumar, U. Deshpande, and N. K. Sahoo;

Surface and Coatings Technology (Under review).

70. 4.**Role of work function in field emission enhancement of Au island decorated vertically aligned ZnOnanotapers**

Avanendra Singh, Kartik Senapati, Mohit Kumar, Tapobrata Som, Anil K Sinha, and Pratap K. Sahoo

Applied Surface Science (Under review).

71. **Atom beam sputtered Ag-TiO_2plasmonicnanocomposite thin films for photocatalytic applications**

Jaspal Singh, Kavita Sahu, A. Pandey, Mohit Kumar, Tapas Ghosh, B. Satpati, Tapobrata Som, S. Varma, D. K. Avasthi, and Satyabrata Mohapatra; *Applied Surface Science(Under review).*

72. **Suppressed B_{c2} in a Superconducting / Ferromagnetic bilayer,**

A Gaurav, B. R. Sekhar, P. S. Anil Kumar, D. Samal (under review)

73. **Band gap Modulation in SnO_2 Microstructures by Pb-doping,**
S. N. Sarangiand D Samal (communicated)

74. **Interfacial conditions for superconductivity in epitaxial hetero-structures with infinite layer cuprates**
D Samal et al. (Submitted to Nature Communications)

4.3. Conference Proceedings :

1. **Gluon fusion contribution to HBB (B = H,ã,Z) at the LHC,**
Ambresh Shivaji, Pankaj Agrawal and Debashis Saha;
8th International Workshop on QCD Theory and Experiment (QCD@Work 2016), arXiv preprint arXiv:1609.04790.

2. **Building of a Bakelite Resistive Plate Chamber Proto- type: Proceedings of the XXI DAE-BRNS High Energy Physics Symposium,**
H. Neog, S. Rudra, M. R. Bhuyan, S. Biswas, B. Mohanty, R. Mohanty, P. K. Sahu, and S. Sahu: , *Springer Proceedings in Physics 174, DOI 10.1007/978-3-319-25619-1-81, Springer International Publishing Switzerland 2016*

3. **Proceedings of 18th International Conference on Radiation Effects in Insulators (REI-18)**
Eds. D. K. Avasthi, A. Tripathi, Tapobrata Som, D. Kanjilal, and Christina Trautmann
Nuclear Instruments & Methods in Physics Research Section B – Beam Interaction with Materials and Atoms, Vol. 379 (2016).

4. **Recent inclusive tt cross section measurements**
A. K. Nayak, on behalf of the ATLAS and CMS Collaborations.
9th International workshop on the CKM Unitarity Triangle(CKM2016) 117, CMS-CR-2017-094

5. **Complex magnetic behavior in $GdCrO_3$,**
Sudipta Mahana, U. Manju and D. Topwal;
AIP Conference Proceedings 1832, 130046 (2017)

6. **Optical and low temperature magnetic properties study on sol-gel derived misfit calcium cobaltite,**
Avinna Mishra, Sudipta Mahana, Dinesh Topwal, U Manju, Sarama Bhattacharjee;
AIP Conference Proceedings, 1832,030019 (2017)

7. **Thermoelectric properties of ternary half-HeuslarLuPdBi,**
A. Mukhopadhyay, S. Mahana, S. Chowki, D. Topwal, and N. Mohapatra;
AIP Conference Proceedings 1832, 110024 (2017)

8. **$CH_3NH_3PbI_3$ based solar cell: Modified by antisolvent treatment,**
Pronoy Nandi, ChandanGiri, Umesh Bansode and D. Topwal;
AIP Conference proceedings, 2017, 1832, 080065.

COLLOQUIA AND SEMINARS

5.1 COLLOQUIA

S.N.	Date	Name & address of speaker	Title
1	16.5.2016	Dr.Arun K. Pati, HRI, Allahabad	Beyond Heisenberg's Uncertainty Relation
2	26.7.2016	Prof. Ashok Das (University of Rochester)	Solving Hydrogen Atom using Group Theory
3	11..8.2016	Dr. Yogesh Kumar Gupta, BARC, Mumbai	Study of fission dynamics and nuclear viscosity
4	11.11.2016	Prof. Amitava Datta, INSA Sr. Scientist, Calcutta University, Kolkata	The quest for elementary particles : from atoms to the Higgs boson
5	28.11.2016	Dr. Narayan Sahoo, Department of Radiation Physics , UT MD Anderson Cancer Center, Houston, Texas, USA	Optimization of efficacy of Radiation Therapy:Application of Physics in Oncology
6	20.12.2016	Prof. M.P.Das, Australian National University,Australia	Metamaterials
7	24.1.2017	Prof. Saroj Prasad Dash, Chalmers Universityof Technology, Gothenburg, Sweden	Spintronics with 2D materials heterostructures
8	16.02.2017	Prof.D.P.Mahapatra, Ex-Officer, IOP	ERE, the all pervading Red Space Glow: What do we know about it?
9	07.03.2017	Dr.Anosh Joseph, ICTS	Supersymmetry on a spacetime Lattice

5.2 SEMINARS

S.N.	Date	Name & address of speaker	Title
1	7.4.2016	Dr. Raj Kumar Das, Stellenbosch University, South Africa	Metal-Organic Frameworks: An Emerging Porous Material
2	12.4.2016	Dr. Priyadrashni Dash, PDF	Synthesis of Zn0 nanostructures and their photocatalyticactivities offer ion implantation
3	13.4.2016	Dr. Debakanta Samal, IOP	Designed Quantum Materials and Emergent Phenomena
4	15.4.2016	Arnab Dasgupta, PDF	Common Origin of the 3.55 KeVXRayLine,Dark Matter and Neutrino Mass
5	15.4.2016	Dr. Dipanjan Bhattacharya (NUS, Singapore)	Mechanobiological understanding of tissue patterning during Zebrafishneurulation
6	18.4.2016	Dr. Nilanjana Kumar, Department of Physics, Northern Illinois,University	Vectorlike leptons at the Large Hadron Collider
7	28.4.2016	Prof. Anand Yethiraj (MUN, Canada)	Far-from-equilibrium assembly in emulsions
8	6.5.2016	Dr. Biswanath Samantaray, SINP, Kolkata	Spin dynamics and Magnetic Anisotropy of Magnetic ThinFilms using Ferromagnetic Resonance
9	20.05.2016	Dr.Arun K. Pati, HRI, Allahabad	Beyond Heisenberg's Uncertainty Relation
10	19.05.2016	Dr. Pranati Rath, PDF	Analysis of CMB with foregrounds
11	20.05.2016	Dr.M.M. Mondal, IOP Visitor	Spin structure of proton at RHIC
12	3.06.2016	Dr. Issam Ali, Muscat, Oman	Packing and ejection of DNA from phages
13	07.06.2016	Dr.(Ms) Paramita Dutta, PDF	Transport properties of a helical ring ring with long-range hopping
14	09.06.2016	Nivedita Bhadra IISER, Kolkata	The Kapitza Pendulum : A model for studying topology change

15	10.06.2016	Advocate (Ms.) Rama Sarode, Socio-Legal Consultant and Trainer,Secretary-Sahyog Trust, Pune	Journey of Laws related to Women
16	10.06.2016	Advocate (Ms.) Rama Sarode, Socio-Legal Consultant and Trainer,Secretary-Sahyog Trust, Pune	Laws against Sexual Harassment of women at workplace
17	14.06.2016	Dr. Krishna Mohan Parattu (IUCAA)	Variational Principle for Gravity with Null Boundaries
18	20.06.2016	Dr.M.M. Mondal, ETH Zurich, Switzerland	Spin structure of proton at RHIC
19.	29.06.2016	Dr. P. K. Tyagi, Delhi Technological Univ., Delhi	Exotic structural and magnetic properties of Fe3C,Co and Ni-filled Carbon nanotubes
20.	30.06.2016	Dr. Souvik Banerjee, IOP	Λ Toy Model of Black Hole Complementary
21.	01.07.2016	Dr.S.L. Samal, NIT, Rourkela	Intermetallics: Complex, Metallic, and Diverse Chemistry. Case Studies in R-Mn-Au (R = Y, Gd) Systems
22.	04.07.2016	Dr. Ronald Benjamin (Dusseldorf, Germany)	Investigating Statistical Mechanics problems via Molecular Simulations: Two Case Studies. (i)Thermodynamics of Buettiker-Landaues Brownian Motor. (ii)Solid-Liquid Phase Transition
23.	07.07.2016	Prof. B.Dasgupta, University of Alabama	aotic Magnetic Field lines: their effects on charged particle motion and energization
24.	08.07.2016	Dr. Siba P. Das, Columbia	A brief discussion on Higgs boson phenomenology at the LHC and LHeC
25.	08.07.2016	Dr.Sibhajit Sarker, S.N.Bose Centre, Kolkata	Spin dynamics and topological excitations in layered magnetic systems
26.	12.07.2016	Prof. Shubho R. Roy (Assistant Professor, IIT Hyderabad)	Computational Complexity and Cosmological Singularities
27.	13.07.2016	Prof. Binoy K. Patra, IIT, Roorkee	Quarkonium in a medium
28.	15.07.2016	Dr. Sachin Jain, Cornell University	Casuality constraint from conformal field theory
29.	18.07.2016	Dr.Suman Chowdhury, University of Calcutta	Electronic and optical properties of disordered graphene
30.	19.07.2016	Prof. M. Soeb, Aligarh Muslim University	Variational Monte Carlo Technique and Energies of p-shell Hypernuclei
31.	26.07.2016	Prof. Ashok Das (University of Rochester)	Solving Hydrogen Atom using Group Theory
32.	27.07.2016	Dr. Sayantan Choudhury,TIFR,Mumbai	COSMOS-e-GTachyon(from String Theory)
33.	03.08.2016	Dr.BijoyDaga, SINP, Kolkata	Phase separation transition and spatial correlations of reconstituting k-mersin one dimension
34.	04.08.2016	Dr. Jayant Kumar Dash, Associate Prof & HOD Dept of Burns, Plastic & Reconstructive Surgery IMS & SUM Hospital(Siksha 'O' Anusandhan University)	BURNS DEMAND ATTENTION
35.	09.08.2016	MinatiBiswal	Dynamical Restoration of Z_N Symmetry in SU(N)+ Higgs Theories
36.	09.08.2016	Dr. Mahendra Mali, IISER, Pune	Quadratic forms and light-cone gravity
37.	10.08.2016	Prof. S. M. Bhatterjee, IOP	Surprises with DNA
38.	11.08.2016	Dr. Yogesh Kumar Gupta, BARC, Mumbai	Study of fission dynamics and nuclear viscosity
39.	12.08.2016	Prof. Bhanu Pratap Das, Tokyo Institute of Technology, Japan	Electric Dipole Moment of the Electron: Probe of New Physics Beyond the Standard Model

40.	16.08.2016	Prof Diana Thongjaomayum, NEHU, Shillong	Avalanches in Nonequilibrium Random-fieldIsing Model (RFIM)
41.	18.08.2016	Dr. Shankhdeep Chakrabortty (Groningen, Netherlands)	Tensionless superstrings from worldsheet perspective
42.	22.08.2016	Dr. Rajeev Kumar Jain, CP3 Origins, Denmark	Cosmological Inflation, Primordial Magnetic Fields and their non-Guassian imprints
43.	23.08.2016	Dr. Tamoghna Das, U Marykand, USA	Morphology dictated heterogeneous dynamics in two-dimensional aggregates
44.	09.09.2016	Professor Monoranjan Guchait, TIFR, Mumbai	Light Higgs Bosons at the LHC
45.	14.09.2016	Dr. Garima Mishra, Dept. of Physics, IIT, Kanpur	DNA Unzipping and protein-DNA interactions
46.	20.09.2016	Dr S B Ota (Institute of Physics)	2D XY model and spin wave excitation
47.	21.09.2016	Prof. Damien Foster, Coventry university, UK	Frustration effects in lattice models of polymers
48.	26.09.2016	Dr. PrasantaTripathy, IIT, Chennai	Geroch Group in Einstein Spaces
49.	26.09.2016	Mr. Shubhro (NIT Agartala)	Glancing angle deposition technique incorporatedelectron beam deposition system and fabrication of nanostructure
50.	27.09.2016	Prof. Sudipta Sarkar (IIT Gandhinagar)	Holography, Second Law and Higher Curvature Gravity.
51.	30.09.2016	Prof. Mofazzal Azam, BARC, Mumbai (Retired)	Landau Singularity and the PerturbativeSeries in QED
52.	03.10.2016	Dr. Sangram Das, IMS Bhubaneswar)	Studies of magnetic and ferroelectric effects in doped ferroelectrics
53.	20.10.2016	Dr. Biplab Pal, Kalyani University	Electron states, charge and spin transport in lowdimensional systems
54.	24.10.2016	Dr. Jehova JireL. Hmar, NIT, Agartala	Growth and Characteristics of Semiconductor-Polymer Nanocomposites for Flexible Electronic and Optoelectronic Devices
55.	26.10.2016	Dr. Sayantan Choudhury, Department of Theoretical Physics, Tata Institute of Fundamental Research, Mumbai	CMB from EFT
56.	28.10.2016	Dr. Sayantan Choudhury, Department of Theoretical Physics, Tata Institute of Fundamental Research, Mumbai	Bell violation in the Sky
57.	03.11.2016	Dr. Biplab Bhattacharjee, S.N. Bose Centre, Kolkata	Spontaneous Evolution of Long Range Correlations in Dynamical Systems
58.	08.11.2016	Prof. T. Pradhan, Ex-Director, IOP	Magneto - Electric Effects in Hydrogen Atom
59.	11.11.2016	Prof. Amitava Datta, INSA Sr. Scientist, Calcutta University, Kolkata	The quest for elementary particles : from atoms to the Higgs boson
60.	15.11.2016	Dr. V. Madhurima, Central University of Tamil Naidu, Thiruvarur	Self-assembled liquid droplets

61.	17.11.2016	Dr. Pramoda Kumar Nayak, Ulsan National Institute of Science and Technology (UNIST),Republic of Korea	Two Dimensional Materials and Their Heterostructures
62.	22.11.2016	Dr. Swastik Bhattacharya, IISER, Trivandrum	Fluctuation Dissipation and Area Quantisation of Black Hole Membrane
63.	23.11.2016	Prof. Pabitra Sen, Department of Physics and Astronomy University of North Calorina	What is Dielectric Enhancement and Why
64.	24.11.2016	Dr. Pradheesh R, IIT Madras, Chennai	MAGNETOTRANPSORT IN DISORDEREDDOUBLE PEROVSKITE
65.	28.11.2016	Dr. Narayan Sahoo, Department of Radiation Physics , UT MD Anderson Cancer Center, Houston, Texas, USA	Optimization of efficacy of Radiation Therapy:Application of Physics in Oncology
66.	06.12.2016	Prof. Bir Bikram Singh, Department of Physics, Sri Guru Granth Sahib World University Fatehgarh Sahib-140406, Punjab	Clustering effects and decay analysis ofthe light mass N=Z and N≠Z composite systems formed in heavy ion collisions
67.	09.12.2016	Prof. M.P.Das, Australian National University,Australia	DFT Theory and Applications
68.	14.12.2016	Prof. M.P.Das, Australian National University,Australia	DFT Theory and Applications
69.	19.12.2016	Dr. P.K.Rath, INFN, Italy	Neutron production at small tandem & future perspective
70.	20.12.2016	Prof. M.P.Das, Australian National University,Australia	Metamaterials
71.	23.12.2016	Prof. GaganMohanty, TIFR, Mumbai.	What next at the LHC?
72.	04.01.201	Dr.Ganapathi Sahoo (University of Rome Tor Vergara)	Role of helicity in three dimensional turbulence
73.	05.01.201	Dr. Chandra Shekhar Max Planck Institute for Chemical Physics of Solids, 01187 Dresden, Germany	Recent advances in topological materials
74.	05.01.201	Dr. Debajyoti Sarkar, Ludwig Maxmilian University, Munich	Connecting holographic complexity and bulk entanglement
75.	06.01.201	Mayukh Raj Gangopadhyay, Department of Physics, University of Notre Dame	Observational Constraints on Brane-World in The Era of Precision Cosmology
76.	10.01.201	Prof. Y. P. Viyogi (DAE Raja Ramanna Fellow, VECC, Kolkata	Designing Experiments in Nuclear and High Energy Physics
77.	11.01.201	Prof. Y. P. Viyogi (DAE Raja Ramanna Fellow, VECC, Kolkata	Designing Experiments in Nuclear and High Energy Physics
78.	12.01.201	Prof. Y. P. Viyogi (DAE Raja Ramanna Fellow, VECC, Kolkata	Designing Experiments in Nuclear and High Energy Physics
79.	13.01.201	Satyajit Seth, Johannes Gutenberg-Universitat Mainz	Combine and Conquer
80.	16.01.2017	Dr. Satyaki Kar (IACS, Kolkata)	Two rate periodic protocol with dynamics driven through many cycles
81.	17.01.2017	Dr. Lobsang Dhargyal, Institute of Mathematical Sciences, Chennai.	Phenomenological studies of the observed anomalies in the tau sector

82.	18.01.2017	Dr. Ashis Kumar Nandy, Department of Physics and Astronomy, Uppsala University, Uppsala, Sweden	Non-trivial topology : Atomic-scale skyrmion in chiral magnets
83.	18.01.201	Dr. Samrat Bhowmick, IACS, Kolkata	AdS/CFT via Radon Transform
84.	20.01.2017	Dr. Chandana Mondal, Weizmann Institute of Sciences, RehovotIsreal	The Sand pile Revisited : Computer Assisted Determinationof Constitutive Relations and Breaking of Scaling
85.	23.01.2017	Dr. Satyaprasad P Senanayak, Royal Society Newton International Fellow,Cavendish Laboratory, University of Cambridge, United Kingdom	Understanding Charge Transport in Lead-Halide Perovskite
86.	24.01.2017	Prof. Saroj Prasad Dash, Chalmers Universityof Technology, Gothenburg, Sweden	Spintronics with 2D materials heterostructures
87.	27.01.2017	Dr. Rohan Poojary, TIFR	S-Matrix Bootstrap
88.	07.02.2017	Dr. Biswajit Karmakar Dept. of Physics, IIT Guwahati.	Nonzero theta13 in the context of flavor symmetry: from leptogenesis to dark matter
89.	08.02.2017	Dr. Swarup Kumar Panda EcolePolytechnique, France	First Priciple simulations of strongly correlatedMaterials: a DFT & DMFT perspective
90.	10.02.2017	Professor Pinaki Banerjee, IMSc., Chennai.	Sine-Gordon Theory: Entanglement Entropy and Holography.
91.	13.02.2017	Dr. Abhijit Ghosh Brandeis University, Massachusetts, USA	Faceted particles formed by the frustrated packing of anisotropic colloids on curved surfaces
92.	16.02.2017	Prof. D. P. Mahapatra, Ex-Officer, IOP	ERE, the all pervading Red Space Glow: What do we know about it ?
93.	21.02.2017	Prof. D. P. Mahapatra, Ex-Officer, IOP	Radiation Detection (Part-I)
94.	21.02.2017	Prof. A.Viramani, IOP	Stability of Schwarzschild -- a talk in honor of late Prof C V Vishveshwara
95.	22.02.2017	Prof.D.P. Mahapatra,Ex – Professor,IOP	Radiation Detection (Part-II)
96.	23.02.2017	Prof. Bhaskaran Muralidharan, Department of Electrical Engineering, IIT Bombay, India	Quantum-dot heat engines, quantum clocks and a Landauerprinciple for time-keeping
97.	27.02.2017	Jessica M. Turner, Durham University, U.K.	Creating the Baryon Asymmetry from Lepto-Bubbles
98	01.03.2017	Prof. D. P. Mahapatra Ex Professor of IOP	Lecture on Radiation Detectors
99	01.03.2017	Prof. A.Mishra, I.I.T New Delhi	
100	02.03.2017	Prof. Sourin Das, IISER Kolkata	Non-local multi-particle geometric phases in electronic intensity interferometry
101	03.03.2017	Dr. Poonam Mehta JNU New Delhi	Hunt for leptonic CP violation and impact of newphysics

102	06.03.2017	Prof. S.D. Mahanti, Michigan State University, USA	Classical and Quantum Time Crystals – Spontaneous breaking of time translation symmetry
103	07.03.2017	Dr. Anosh Joseph, ICTS	Supersymmetry on a spacetime Lattice
104	08.03.2017	Prof. D.P. Mahapatra	Radiations, their detection and Detectors
105	09.03.2017	Prof. D.P. Mahapatra	Radiations, their detection and Detector
106	10.03.2017	Dr. Bhabani Prasad Mandal, BHU	Abelian Projection in Lorentz Gauge?
107	10.03.2017	Prof. S. D. Mahanti, MSU, USA	Floquet-Time Crystals
108	15.03.2017	Dr. Amit Dutta Banik, SINP	Study of Two component WIMP-FImP dark matter model
109	15.03.2017	Dr. Alekha Chandra Nayak, IITK	Pion decay within the framework of Very Special Relativity
110	16.03.2017	Prof. Arijit Kundu, IITK	Periodically driven topological systems: Where we are now
111	16.03.2017	Dr. Jyotiranjan Beuria, HRI	Phenomenology of the Next-to-Minimal Super Symmetric Standard Model
112	20.03.2017	Dr. Jashashree Ray, SN Bose NCBS Kolkata	Multiferrocity in BiFe1-xCoxO3 & EDL based FET
113	22.03.2017	Dr. Bhaskar Chandra Behera	Strain and crystal structures dependence of magnetic interface coupling in La0.7Sr0.3MnO3/SrRuO3 superlattices
114	27.03.2017	Dr. Ananda Hota, UM-DAE CBS	First Results from from GMRT Observation of new Black-hole Galaxy Systems Discoverd by RAD@homecitizen-scientist
115	28.03.2017	Ashish Shukla, TIFR	Symmetry Constraints in Inflation
116	29.03.2017	Avijit Mishra	Maximum Entropy Principle in Quantum Thermodynamics

5.3 LECTURES DELIVERED BY THE INSTITUTE MEMBERS

TITLE OF TALK	EVENT / PLACE & DATE
Prof. S. M. Bhattacharjee	
Surprises with DNA	Colloquium, IOP
DNA and condensed matter physics	Plenary Talk at CMDAYS 2017 at Aizwal
Bubble induced phases in DNA	ICMS (International conference) at Tripura University Agartala
Surprises with DNA	Colloquium, TIFR Hyderabad
Efimov Physics and DNA	miniStatPhys, Kolkata (Calcutta University)
DNA near its melting point	Workshop on "DNA Physics", BITS Pilani
Prof. A. M. Srivastava	
High density QCD phase transitions inside neutron stars: glitches and gravitational waves	First Workshop on Beyond Standard Model Phenomenology" at IISER Mohali (PHENO1@IISERM) during 6th to 9th of April, 2016
Strongly interacting matter at high baryon density: from neutron superfluidity to color superconductivity	PRL conference on Condensed Matter Physics" at PRL, Ahmedabad, during 11th April to 13th April 2016
Introduction to Quantum Mechanics for plus-two teachers	DAV CSPur, Bhubaneswar 17th May, 2016
Flow power spectrum in heavy-ion collisions	International Conference on "Compressed Baryonic Matter (CBM) Physics," at Sikkim Manipal Institute of Technology, Rangpo, Sikkim, 22nd June 2016
Flow as a probe of the phases of QCD matter formed in heavy-ion collisions	International Symposium, A Journey from Nuclei to Quarks held at VECC, Kolkata, 29th June,2016.
Introduction to QCD and Quark-gluon plasma	at the Physics Dept., IIT Indore, July 4-8, 2016.
Cosmology" given at the "Faculty Development Program	at the College of Engineering and Technology (CET), Bhubaneswar, 31st Aug. 2016.

Investigating Cosmic String theories with Liquid Crystal Experiments	IIT Roorkee chapter, at the Physics Dept. IIT Roorkee, on the topic, 6th Oct. 2016.
Effect of superfluid vortices and magnetic field on the power spectrum of flow fluctuations	International workshop "Hadronic matter under extreme conditions-2016", JINR, Dubna, Russia, 3rd Nov. 2016
Investigating Cosmic string theories with Liquid Crystal Experiments	Physics Dept., Delhi University, 7th Nov. 2016
From the universe to relativistic heavy-ion collisions: CMBR fluctuations and flow anisotropies	ndian Association for the Cultivation of Science, 22nd Nov. 2016.
Investigating Cosmic string theories with Liquid Crystal Experiments	the Indian Association for the Cultivation of Science, 23rd Nov. 2016.
setting initial conditions for inflation with reaction difusion equation	International conference "Saha Theory Workshop: Aspects of Early Universe Cosmology", SINP, Kolkata, 16-20 Jan, 2017.
Detection of Gravitational waves, a new window to the Universe	Physics Dept. BHU, Varanasi on, 22nd Feb. 2017
QGP in lab and in the universe	Physics Dept., Utkal Univ. on ", 9th March, 2017
Effect of magnetic field on flow fluctuations in relativistic heavy-ion collisions	workshop on "Magnetic field and vorticity in heavy-ion collisions, March 27-30 , 2017, Phys. Dept., UCLA, USA.
Detection of Gravitational waves, a new window to the Universe	IIT Indore on 5th July, 2016 (**POPULAR TALK)**
Detection of Gravitational waves, a new window to the Universe	Regional Science Center, Bhubaneswar, 11th May, 2016
Detection of Gravitational waves, a new window to	Institute of Mathematics and Applications, Bhubaneswar,
the Universe	11th Aug. 2016.
Detection of Gravitational waves, a new window to the Universe	IIT Roorkee on the topic, "Detection of Gravitational waves, a new window to the Universe", 5th Oct. 2016.
The Universe and Dark Energy	The Science Movement" organization at Suryansh Hotel, 20th Dec 2016
Learning science, doing research, Three Idiot's way	NISER, Bhubaneswar 14th March, 2017.
Prof. S. Varma	
Nanotechnology and Atomic Force Microscopy	Faculty Development Program in the department of Physics, held at The College of Engineering and Technology (CET), Bhubaneswar (Sept 2016).
A brief introduction to Fractals with Relations to Rough Ion Bombarded Surfaces	the International School on the Ions Beams in Materials Science (IBMEC 2016), held at IUAC, New Delhi (Sept 2016).
Scaling Properties Applied to rough Self A□ne surfaces and X Ray Photoelectron spectroscopy (XPS)	International School on the Ion Beams in Materials Science (IBMS-2016), at IUAC, New Delhi (Sept 2016).
Enhanced Photoabsorption and Super-Paramagnetism in Cobalt implanted TiO_2	International conference on Ions Beams in Materials Engineering and Characterizations 2016 (IBMEC 2016), held at IUAC, New Delhi (Sept 2016).
Interaction of DNA with oxidised Silicon Nanostructures	International conference on Smart Materials Applications (ISMA-2016), held at SOA-ITER, Bhubaneswar (Dec 2016).
DNA as a Sensor of Nanoparticles:Unzipping and changing Per sistence Length of DNA	International conference on Advances in Biological Systems and Materials Science in NanoWorld (ABSMSNW -2017) held at BHU, Varanasi (Feb 2017).

Nanoscience and Nano-Biotechnology	Refresher Course in Physical Sciences held at Utkal University, Bhubaneswar (Mar. 2017).
Research Activities at IOP related to SAC/ISRO	Space Application Center (SAC) meeting, held at Utkal University, Bhubaneswar (March 2017).
Prof. P. Agrawal	
Three-hour lectures on 'Quantum Information and Entanglement', in "Faculty Development Programme"	College of Engineering and Technology, Bhubaneswar, August 30 – September 3, 2016.
Bell Nonlocality and Entanglement	2nd International Conferenceon Quantum Foundations 2016 (ICQF16)" National Institute of Technology (NIT), Patna, October 17-21, 2016
Prof. B. R. Sekhar	
Surface states of topological insulators	Optics-2017, NIT, Calicut
Research and Higher Education opportunities in science	Model Higher Secondary School, Kollam, Kerala (Popular talk)
Prof. P. V. Satyam	
Probing Thin film Interfaces with Electron Microscopy	International Conference on Electron Microscopy, EMSI, at Varanasi, IIT BHU, 3 June 2016
Anisotropy Driven Hetero-Nanostructures (SiGe and AuAg) on High Index Silicon Substrates, Symposium on "Contemporary Issues in Condensed Matter Systems	Department of Physics, IISc, Bangalore, 15 June 2016
Growth and applications of Au, Ag, ZnO and GeO2 Nanostructures	Materials Research Centre, CEMAT, IISc Bangalore, 19 July 2016
Atomic Structure of Materials	College of Engineering and Technology (CET), Bhubaneswar, 01 Sept 2016
Ion Beam Facilities at Institute of Physics	BRNS program at CET, Bhubaneswar, 22 October 2016
Ion beam induced Endotaxy	International conference on Ion Beam Modification of Materials, 2016 (IBMM 2016), Wellington, New Zealand, 3 November 2016
Self-Assembled Silver Endotaxial Nanostructures in Silicon	International conference on Smart Materials and Applications (ISMA), SOA University, ITER, Bhubaneswar, 17 December 2016
Electron Microscopy: Direct Observation of Nanoscale structures	Indian Academy of Science sponsored workshop in Frontiers in Materials at Department of Chemistry, Revanshaw University, Cuttack, 7 Jan 2017
Atom by Atom Self-assembly: The Nature's Play (Understanding the Bottom-up Approac)	3rd BK Mahanti Memorial Lecture, Department of Physics, Ravenshaw University, Cuttack, 10 March 2017
Prof. S. Mukherji	
Gauge theory correlators on time dependent backgrounds	IMSc, April, 2016
AdS/CFT and time dependent backgrounds	BHU, November, 2016
Simple models displaying spontaneous symmetry breaking	Physics Dep,Gangtok University, October, 2016
National Science day talk,	Berhampur University, Feb, 2017
Prof. T. Som	
Surfing ion-beam fabricated self-organized silicon nanofacets for cold cathode electron emission sites	Asian Consortium on Computational Materials Science Theme Meeting on First-Principles Analysis and Experiments: Role in Energy Research, SRM University, Chennai on September 23, 2016.
Probing electron emitting sites from Si nanostructures using local probe microscopy	College of Engineering and Technology, Bhubaneswar on September 28, 2016.
Strong uniaxial magnetic anisotropy in Co films on highly ordered grating-like nanopatterned Ge	International Conference on Smart Materials and Applications (ISMA-2016) at Siksha 'O' Anusandhan University, Bhubaneswar onDecember 15, 2016.

Ion Induced Defect-mediatedTunability in Optoelectronics Properties of TiO_2 Thin Films	Accelerator Users' Workshop at Inter-University Accelerator Centre, New Delhi on December 16, 2016.
Transition metal-doping in TiO_2 Thin Films by ion implantation: A study on tunable magnetic and optical properties	Accelerator Users' Workshop at Inter-University Accelerator Centre, New Delhi on December 16, 2016.
Nanoscale functionalization of ion-beam fabricated self-organized silicon nanofacets for cold cathode electron emission site	atInternational Conference on Advances in Biological Systems and Materials Science in Nano World (ABSMSNW) at IIT-BHU on February 21, 2017.
Prof. S. K. Patra	
SERC School on Nuclear Physics	University of Kashmir, Srinagar, 16th May to 6th June 2016
Tidal deformibility of neutron and hyperon star with relativistic mean field equation of states	Department of Physics, Panjab University, Chandigarh, 15-18 March 2017, INTERNATIONAL CONFERENCE IN NUCLEAR PHYSICS WITH ENERGETIC HEAVY ION BEAMS
Ternary fission of 252Cf using temperature dependent relativistic mean field approach	National conference on Nuclear and Accelerator Physics (NCNAP-2016), October 4-6, 2016. Central University of Jharkhand, Ranchi
Prof. P. K. Sahu	
GEM detectors at High Energy Lab in	IOP at UGC Sponsored National Seminar on Recent Trends in Physics(RTP), Institute of Physics, Bhubaneswar with Department of Physics, Maharishi College Of Natural Law, Saheed Nagar, Bhubaneswar, Odisha, January 8-9, 2017.
Prof. A. Virmani	
Stability of Schwarzschild	- a talk in honor of late Prof. C V Vishveshwara, - Discussion meeting ``Remembering C V Vishveshwara'' at International Center of Theoretical Sciences (ICTS), Bangalore - Chennai Mathematical Institute, Chennai - IOP Bhubaneshwar
Internal structure of AdS black holes	- Invited seminar at HRI Allahabad, April 2016 - Invited ``Quantum Spacetime'' seminar at TIFR Mumbai, August 2016 - IPhT, CEA Saclay, France, Nov 2016 - Internal seminar at ULB Brussels, Nov 2016 - Indian Strings Meeting, Pune, India, December 2016 - Recent developments in high energy and condensed matter theory, Indian Association for Cultivation of Science, Kolkata, Feb 2017 - Integrability in Supergravity, LMU Munich, March 2017
Prof. S. K. Agarwalla	
Known and Unknown Parameters in Neutrino Oscillation	UGC-DRS Sponsored National Seminar on Current Trends in Physics at Department of Physics, Utkal University, Bhubaneswar, Odisha, India, 31st March, 2017
India-based Neutrino Observatory: The Search for Invisible Neutrinos	DST-Inspire Internship Programme at Schoolof Biotechnology, KIIT University, Bhubaneswar, India, 13th January, 2017
Fundamental Unknowns in Neutrino Oscillation and their Future	ICTP, Trieste, Italy, 13th December, 2016
Neutrino Oscillation Parameters: Present Status and Future Roadmap	82nd Annual Meeting of Indian Academy of Sciences, IISER Bhopal, Bhopal, 4th November, 2016

Addressing Fundamental Unknowns in Neutrino Oscillation	InstitutoNazionale di FisicaNucleare (INFN), Milan, Italy, 29th November, 2016
Neutrino Mass Hierarchy and CP-violation: How to get them?	workshop on New Frontiers in Electroweak Interactions of Leptons and Hadrons, Aligarh Muslim University, Aligarh, India, 2nd November, 2016
A Thrilling Journey into the World of Neutrinos	Department of Physics, College of Engineering and Technology (CET), Techno Campus, Bhubaneswar, 22nd October, 2016
Three-Flavor Oscillations	Pedagogical lecture given during the High Energy Physics (HEP) school on LHC and Neutrinos at Institute of Physics, Bhubaneswar, 20th October, 2016
Working Group 5 (Neutrinos Beyond PMNS) Summary Talk	The Nu Fact 2016 Conference, Quy Nhon,Vietnam,27th August, 2016
Impact of Light Sterile Neutrinos at Long-baselines	The NuFact 2016 Conference, QuyNhon, Vietnam, 26th August, 2016.
Physics Reach of DUNE in 3+1 Scheme	the DUNE Physics Working Group meeting, Fermilab, USA, 26th April, 2016
Neutrino Mass Hierarchy and CP-violation: Future Prospects	the PHENO1@IISERM workshop, IISER Mohali, 6th April, 2016
Prof. A.Saha	
Quantum Charge Pumping through resonant crossed Andreev reflection in superconducting hybrid junction of Silicene	HRI, Allahabad, 16th February 2017.
Prof. S. Mandal	
Frustrated Magnetism: Kitaev model and beyond	A 2hr interactive talk given at CET, Bhubaneswar on the workshop "Advance development in applied physics" on 25th October, 2016
Prof. S. Sahoo	
Raman scattering of atomically thin Van der Waal solids	Annual Seminar of the Department of Physics, Ravenshaw University Cuttack on 12.04.2017
Magnetism and Matter	Content Enrichment Programme for PGTs in Physics for DAV public schools of Odisha
Prof. A. K. Nayak	
Higgs to difermions result at CMS	on behalf of the CMS collaboration, Higgs Hunting 2016, 31st August to 2nd September, LPNHE (UPMC), Paris.
Recent inclusive ttbar cross section measurements	on behalf of the ATLAS and CMS collaborations, 9th International workshop on the CKM Unitarity triangle (CKM2016), November 28th to December 2nd, 2016, TIFR, Mumbai.
Tau lepton identification	CMS, Jets@LHC workshop, 21-28 January 2017, ICTS, Bengaluru
Prof. D. Chaudhuri	
Confinement dependent chromosome organization and segregation in bacteria	Indian Statistical Physics Community Meeting, ICTS-TIFR, Bangalore, 18th February, 2017
Boundary compliant compaction and positioning in E.coli chromosome	YIM-Soft Matter 2016, held at Goa, on 18 February, 2017.
Structure and Positioning of Bacterial Chromosome	CompFlu@Hyd 2016, a conference on Complex Fluids held at Hyderabad, 12th December, 2016.
Bacterial Chromosome	the School of Biological Sciences, NISER, Bhubaneswar on 26th October, 2016.
Spatial patterning and dynamics within bacteria	Physics department of IIT- Guwahati, 7th October, 2016
Bidirectional motion of filaments: Competition between motor proteins and passive cross linkers	FOM Institute AMOLF, Amsterdam, The Netherlands, 22nd September, 2016.
Organization, positioning and segregation of bacterial chromosomes	Physics Department, IIT-Bombay, Mumbai, 23rd June, 2016

Prof. S. Banerjee	
Quantum space-time	TIFR Mumbai .
Strings 2016	Beijing, China.
SERC Main School on Advanced Level Theoretical High Energy Physics	Lecture series for the course "Renormalization of The Standard Model
Prof. D.Samal	
Designed Quantum Materials and Emergent Phenomena	IoP Bhubaneswar, April-13, 2016.
Designed Layered Materials and Emergent	UGC sponsored Seminar on Current trends in
Phenomena	nanotechnology" 22nd-23rd October 2016, BJB College, Bhubaneswar, Odisha.
Electronic and magnetic properties of ultra-thin tetragonal CuO layer	workshop on Spintronics and Nanomagnetism, 29th December 2016, Physics Department IIT Delhi.
Novel structural, electronic, and magnetic phenomena at unit-cell level in cuprate based synthetic layers/hybrids,	Indo Japan Workshop on Magnetism at the Nanoscale,1st-3rd December,2016, Institute for Materials Research, Tohoku University, Sendai, Japan.
Synthetic Materials by Atomic-Layer Engineering and Emergent Phenomena, 7th Trilateral Conference on "Nanoscience: Energy, Water & Healthcare	Nanyang Technological University (NTU), Singapore. 5th – 7th December 2016.
Atomic-Layer Engineering: A viable approach to tailor-make high-Tc/exotic superconducting materials	International Conference of Young Researchers on Advanced Materials (IUMRS-ICYRAM 2016), December 11-15, 2016 IISc Bangalore, India.
Thin films of three-dimensional Dirac material Sr_3PbO	International conference on smart materials & applications (ISMA-2016), S 'O'A University, Bhubaneswar.
Manipulating electronic and magnetic phases in atomically engineered layers and hybrids	National Conference on Electron Spectroscopy (NCES-2016), December 22-24, 2016, Toshali Sands Puri.
Layered Quantum Materials and Emergent Phenomena	UGS Sponsored National Seminar on recent trends in Physics, NCES- 08-09, January 2017, Maharishi College, Bhubaneswar.
Nobel Prize in Physics-2016	Utkal University, 6th February, 2017.
Dr. S. N. Sarangi	
Nuclear Techniques & Nano-Science	DAE-IOP Awareness - cum- Workshop on "Nuclear Technologies for Betterment of Tribal's Social Life" at Ekalavya Model Residential School, Mahasingi, Kandhamal district of Odisha during 18th and 19th March, 2017
Activities of Institute of Physics for Multidisciplinary Research and Applications	DAE-BRNS Awareness-cum Seminar on "Role of Atomic Energy & Nuclear Power in the Service of the Mankind" at U. N. College, Soro, Balasore on October 2, 2016
Mr. Ranveer Singh	
An efficient hole-blocking property in $BiFeO_3$ thin films grown by PLD	International Conference on Functional Oxides and Nanomaterials (ICFONM), Saurashtra University, Rajkot on November 11, 2016.
Thickness-dependent photoresponse in *n*-TiO_2/*p*-Si heterostructure	2nd International Conference on Solar Energy Photovoltaic (ICSEP), KIIT University, Bhubaneswar on December 18, 2016.
Growth angle-dependent tunable structural, optical, and electrical properties of MoO_3 thin films	International Conference on Advances in Biological Systems and Materials Science in NanoWorld (ABSMSNW-2017), IIT BHU (Varanasi), Varanasi on February 22, 2017.

5.4. CONFERENCE / WORKSHOP ATTENDED BY IOP MEMBERS

Name	Conference/Workshop details
Prof. S. M. Bhattacharjee	1. CMDAYS2017 at Aizwal; 2. ICMS at Tripura University, Agartala; miniStatPhys, Calutta University, Kolkata; 3. DNA Physics, BITS, Pilani
Prof. A. M. Srivastava	1. First Workshop on Beyond Standard Model Phenomenology at IISER Mohali (PHENO1@IISERM) during 6th to 9th of April, 2016. 2. PRL conference on Condensed Matter Physics" during 11th April to 13th April 2016 3. Utkal Univ. Research Scholars Conclave, 30th April, 2016, as a judge for poster presentation. 4. The International Conference on "Compressed Baryonic Matter (CBM) Physics, at Sikkim Manipal Institute of Technology, Rangpo, Sikkim, 22 June 2016. 5. The International Symposium, A Journey from Nuclei to Quarks held at VECC, Kolkata, 29th June,2016. 6. The International conference: Hadronic matter 2016, JINR, Dubna, Russia, 31st Oct.- 3rd Nov. 2016. 7) 7. The International conference "Saha Theory Workshop: Aspects of Early Universe Cosmology", SINP, Kolkata, 16-20 Jan, 2017. 8. The International Workshop on "Magnetic field and vorticity in heavy-ion collisions, March 27-30, 2017, Phys. Dept., UCLA, USA.
Prof. S. Varma	1. International conference on Ions Beams in Materials Engineering and Characterizations 2016 (IBMEC 2016), held at IUAC, New Delhi (Sept, 2016). 2. International conference on Smart Materials Applications (ISMA-2016), held at SOA-ITER, Bhubaneswar (Dec 2016). 3. International conference on Advances in Biological Systems and Materials Science in NanoWorld (ABSMSNW -2017) held at BHU, Varanasi (Feb 2017). 4. Space Application Center (SCA) meeting, held at Utkal University, Bhubaneswar (March 2017).
Prof. P. Agrawal	1. Faculty Development Programme", College of Engineering and Technology, Bhubaneswar, August 30 - September 3, 2016. 2. 2nd International Conference on Quantum Founda-tions 2016 (ICQF16)" National Institute of Technology (NIT), Patna, October 17-21, 2016.
Prof. S. Mukherji	1. Gauge theory correlators on time dependent backgrounds, IMSc, April, 2016. 2. AdS/CFT and time dependent backgrounds, BHU, Nobember, 2016. 3. Simple models displaying spontaneous symmetry breaking, Physics Dep, Gangtok University, October, 2016. 4. National Science Day talk, Berhampur University, Feb, 2017.
Prof. P. V. Satyam	1. International Conference on Electron Microscopy, EMSI2016, Varanasi (Organized by IIT-BHU), June 2016. 2. Contemporary Issues in Condensed Matter Systems", Department of Physics, IISc, Bangalore, June 2016. 3. International conference on Ion Beam Modification of Materials, 2016 (IBMM 2016), Wellington, New Zealand, 30 October - 3 November 2016. 4. International conference on Smart Materials and Applications (ISMA), SOA University, ITER, Bhubaneswar, 17 - 18 December 2016.

	5. Indian Academy of Science sponsored workshop in Frontiers in Materials at Department of Chemistry, Revanshaw University, Cuttack, 7 Jan 2017. 6. MRSI 2017 – Meeting, IIT Bombay, Mumbai, 14-15 Feb 2017.
Prof. S. K. Patra	1. SERC School on Nuclear Physics, University of Kashmir, Srinagar, 16th May to 6thJune 2016. 2. International Conference in Nuclear Physics with Energetic Heavy ion beams. 3. National conference on Nuclear and Accelerator Physics (NCNAP-2016).
Prof. T. Som	1. Asian Consortium on Computational Materials Science Theme Meeting on First-Principles Analysis and Experiments: Role in Energy Research, SRM University, Chennai, September, 2016. 2. International Conference on Smart Materials and Applications (ISMA-2016) at Siksha 'O' Anusandhan University, Bhubaneswar, December, 2016. 3. Accelerator Users' Workshop at Inter-University Accelerator Centre, New Delhi, December, 2016. 4. International Conference on Advances in Biological Systems and Materials Science in Nano World (ABSMSNW) at IIT-BHU, February, 2017.
Prof. P. K. Sahu	1. CERN for ALICE collaboration from March 25 to April 21, 2016. 2. National Conference on Advanced Detectors for Nuclear, 3. High Energy and Astro-particle Physics- 15-17 February, 2017 4. Bose Institute, Centenary Campus, Kolkata-700 054. 5. ALICE-India Collaboration Meeting - December 1-3, 2016, Guahati University, Gawhati, Assam 6. CERN and GSI for ALICE mini collaboration and ALICE-TPC experiment from September 16 to October 12, 2016; **7.** ALICE-India Collaboration Meeting - August 3-4, 2016, Panjab University, Chandigarh.
Prof. A. Virmani	1. GIAN lecture course on black hole information paradox, June-July 2016, at IIT Gandhinagar. 2. Indian Strings Meeting, December 2016, IISER Pune. 3. String theory: The present and the future, September 2016 4. School on Modular forms and Black Holes, Jan 2017 at NISER Bhubaneshwar. 5. Recent developments in high energy and condensed matter theory, Indian Association for Cultivation of Science, Kolkata, February, 2017. 6. Advanced Strings School, February 2017 in Puri.
Prof. S. K. Agarwalla	1. Academic visit to ICTP, Trieste, Italy, 13th November to 16th December, 2016 including a visit to INFN, Milan, Italy during 28th -30th November, 2016 2. 82nd Annual meeting of Indian Academy of Sciences, IISER Bhopal, Bhopal, India, 4th -6th November, 2016 3. Workshop on New Frontiers in Electro weak Interactions of Leptons and Hadrons, Aligarh Muslim University, Aligarh, India, 2nd-3rd November, 2016 4. India-based Neutrino Observatory (INO) collaboration meeting, Homi Bhabha Centre for Science Education (HBCSE), Mumbai, India, 24th - 25th October, 2016

	5. NuFact 2016 Conference, Quy Nhon, Vietnam, 21st -27thAugust, 2016. 6. First Workshop on Beyond Standard Model Phenomenology at IISER Mohali (PHENO1@IISERM), IISER Mohali, Mohali, India, 6th -9th April, 2016
Prof. S. Mandal	Advanced development in applied physics, at CET, Bhubaneswar on 25th October, 2016
Prof. A. Saha	Conference on "Low dimensional quantum systems" February 15 - 16, 2016 at HRI, Allahabad.
Prof. A. K. Nayak	1. Higgs Hunting 2016, 31st August to 2nd September, LPNHE (UPMC), Paris. 2. 9th International workshop on the CKM Unitarity triangle (CKM2016), November 28th to December 2nd, 2016, TIFR, Mumbai. 3. Jets@LHC workshop, 21-28 January 2017, ICTS, Bengaluru.
Prof. D. Choudhuri	1. Indian Statistical Physics Community Meeting, ICTS-TIFR, Bangalore, February, 2017, 2. YIM-Soft Matter 2016, organized by IIT-Bombay held at Goa, December, 2016. 3. Physics Department, IIT-Bombay, Mumbai from 22-24 June, 2016 to present a seminar, and collaboration with Dr. Amitabha Nandy of IIT-Bombay. 4. Prof. Bela M. Mulder of FOM Institute AMOLF, Amsterdam, and Prof. Cees Dekker, TU-Delft, Delft, The Netherlands, between 12th to 23rd September, 2016. The visit was for a research-collaboration with Prof. Dekker and Prof. Mulder. The travel cost and local hospitality was provided by AMOLF.
Prof. S. Banerjee	1. Advanced String School" in Puri organized by IOP, Bhubaneswar. 2. Strings Attached" held in IIT Kanpur. 3. Saha Theory Seminar" in SINP , Kolkata.
Prof. D. Samal	1. Workshop on Spintronics and Nanomagnetism, 29th December 2016, Physics Department IIT Delhi. 2. Indo Japan Workshop on Magnetism at the Nanoscale,1st-3rd December,2016, Institute for Materials Research, Tohoku University, Sendai, Japan. 3. Nanyang Technological University (NTU), Singapore. 5th – 7th December 2016. 4. International Conference of Young Researchers on Advanced Materials (IUMRS-ICYRAM 2016), December 11-15, 2016 IISc Bangalore, India. 5. International conference on smart materials & applications (ISMA-2016), S 'O'A University, Bhubaneswar. 6. National Conference on Electron Spectroscopy (NCES-2016), December 22-24,2016, Toshali Sands Puri.
	UGS Sponsored National Seminar on recent trends in Physics, NCES- 08-09, January 2017, Maharishi College, Bhubaneswar.

5.5. AWARDS / HONOURS AND RECOGNITIONS

Prof. S. Panda

1. Recipient of Fellow of Indian Academy of Science
2. Recipient of Fellow of Indian National Science Academics Award

Prof. P. V. Satyam

3. MRSI Medal in Materials Science, Feb 2017
4. Fellow of Andra Pradesh Academi of Sciences, 2016
5. Vice President of Electron Microscope Society of India

Prof. A. Virmani

6. Head of the DST Max-Planck partner group between IOP and AEI Potsdam.
7. Editorial Board member of General Relativity and Gravitation, Springer.

Prof. S. K. Agarwalla

8. Winner of the NASI Scopus Young Scientist Awards 2016 - Physics category.

Prof. Debakanta Samal

9. Dr. Debakanta Samal has been appointed as Head of the partner group of Max Planck Institute for Solid State Research at IoP, Bhubaneswar.

Mr. Ranveer Singh

10. Best *ORAL presentation Award*in International Conference on Advances in Biological Systems and Materials Science in NanoWorld (ABSMSNW-2017), Varanasi during February 19-23, 2017.

CONFERENCES AND OTHER EVENTS

6.1 ALUMNI DAY

The 37th Alumni Day was celebrated on 3rd September, 2016. It was chaired by Prof. S. Panda, Director, Institute of Physics and President Alumni Association, IoP. The program started with an academic session which consisted of a series of lectures by our alumni members of IOP and a colloquium by an invited distinguished physicist.

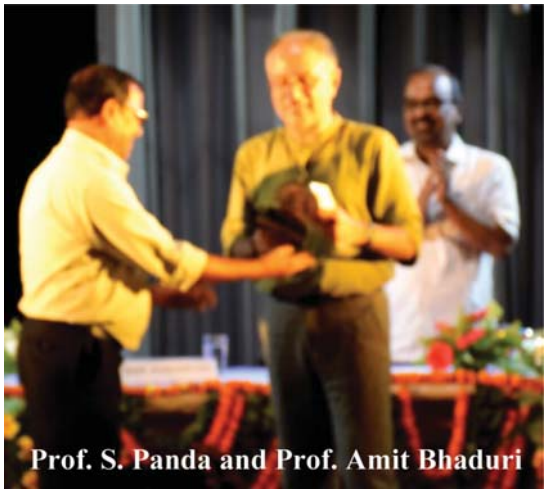
In this session, Alumni Association had organised many lectures viz. Ashwini Kumar


Prof. SadhanaDash

Rath Memorial talk. This year, the Ashwini Kumar Rath Memorial award in Nuclear Physics


Prof. R. Ramaswamy

awarded by the Indian Physics Association, which was instituted by the Alumni Association of the IOP in 2010. Since then Alumni Association of the Institute invites the awardees to deliver the Ashwini Kumar Rath Memorial colloquium at Institute of Physics. This year Ashwini Kumar Rath memorial lecture was delivered by Dr Yogesh Kumar Gupta (BARC Mumbai, awardee 2012) on 11th August, 2016. The Alumni day lectures were delivered by eminent Scientists / Alumni members:Prof. Pijush K. Ghosh, Visua Bharati, delivered Alumni Day Talk entitled "PT-Symmetric Quantum Systems" , Prof. Sadhana Dash, IIT, Bombay delivered Alumni Day Talk entitled "Weibull model of multiplicity


Prof. S. Panda and Prof. Amit Bhaduri


Prof. Amit Bhaduri delivering talk

Distribution in high energy collisions and Prof. Sagata P. Khastgir, IIT, Kharagpur delivered the talk entitled "*Incandescent Vs Laser*". Prof. Ram Ramaswamy, JNU, Delhi delivered Alumni Day Colloquium Talk entitled *"Complexity and Simplicity in Biological Systems"*during the morning session of the Alumni Day function of the Institute.

The evening program started with prize distribution ceremony to the winners of various competitions such as debate, science modeling, and many other competitions organized by the Alumni Association of IOP. It also includes science modeling, essay competition etc. among the school students of various groups. It was followed by a talk by Prof. Amit Bhaduri, Professor Emeritus, JNU entitled *"Danger zones of high growth in India"*. This was followed by the evening cultural programme which was organized by the IOP Alumni Association.The main attraction of this cultural programme was Odissi Dance by Jagruti and Mardal Vadan (duet) by Niranjan Sahoo, Dibakar Parida and Sitar Vadan (solo) by Manmatha Pradhan.

Office Bearers :

Secretary	:	Mr. Ganesh Paul
Faculty Advisor	:	Prof. A. Virmani

6.2. FOUNDATION DAY

Institute of Physics celebrated it's 42nd Foundation Day on September 4, 2016. This is one of the most important events of the Institute, where a large number of persons from academia, media, and administration of the Odisha Government and DAE were invited. Members of the Institute family took active part in the proceedings. On this occasion, a frunction was arranged in the Auditorium of the Institute. Prof. Ramakrishna Ramaswamy, School of Physical Sciences, Jawaharlal Nehru University, New Delhi graced the occasion as Chief Guest and delivered the key note address on the Foundation Day talk entitled "*Women in Science : What we have and what we need*".

In the lecture, Prof. Ramaswamy emphasized that more than ever, diversity is recognized as a valuable and desirable feature of the workplace. As science becomes more collaborative and multidisciplinary approaches are needed to solve problems that are significant at this time, the importance ensuing that the pursuit of science as a career is kept open to all. Many steps have been taken over the years – and many more are still required – to encourage women scientists to pursue their careers and to enhance the gender sensitivity of the work environment in our academic and scientific institutions.

The session was chaired by Prof. Sudhakar Panda, Director, Institute of Physics. Vote of thanks was given by Prof. B. R. Sekhar, Chairman of the Foundation Day Celebration Committee. The programme was concluded by performance of classical, odishi and folk dances of the state of Odisha by Adruta Dance Troupe, a unit of RAWA Academy of the underprivileged children of the society.

6.3 6th Advanced String School

The String Theory group at Institute of Physics, Bhubaneswar organisedthe "*Advanced String School*" (sixth in the series) from February 12 to February 18, 2017. The aim of the school is to stimulate scientific interactions between students and teachers from international community while contributing to the development of scientific research in India.

This school, in particular, was for the graduate students and the postdocs in India working on String Theory. Permanent faculty members also attended the school. This school was open to everyone from the international community working in String Theory as well. The total number of participants were about more than 60 (including local participants).

Organizers of the school were Shamik Banerjee, SudiptaMukherji and Amitabh Virmani.

6.4 National Conference on Electron Spectroscopy

National Conference on Electron Spectroscopy, NCES-2016 Puri. Electron spectroscopic techniques have been playing a vital role in elucidating the origin of various exotic properties of materials, like Graphene, topological insulators, superconductors and other correlated systems which are frontier areas of research in Condensed Matter Physics. Studies based on electron spectroscopy have grown rapidly over the past decades, which prompted the development of big facilities like synchrotron sources around the globe. National Conference on Electron Spectroscopy (NCES-2016) was aimed at providing a platform for those researchers in India practising electronic structure studies using both experimental and theoretical tools to interact closely and exchange ideas. NCES-2016 was jointly organized by Institute of Physics (IOP), Bhubaneswar, Tata Institute of Fundamental Research (TIFR), Mumbai, and Saha Institute of Nuclear Physics (SINP), Kolkata. About 30 invited speakers and 20 senior researchers attended the meeting during December 22-24, 2016 at Toshali Sands, Puri.

Group photo taken during NCES-2016

6.5. Telescope Making Workshop

A telescope making workshop was conducted for school students (class *VIII - XII*) on 19thDec., 2016 as part of "The Astronomy Festival", arranged by Vigyan Prasar, New Delhi, on the occasion of the International Olympiad in Astronomy and Astrophysics (IOAA-2016). Before the workshop, an introductory lecture was given to students on optics, ray diagrams, lenses, and telescopes.

OTHER ACTIVITIES

7. 1. OutreachProgramme

As a part of the Outreach Program of the Institute, following programs were carried out.Some of the outreach activities carried out during this year are described below.

7.1.1. Awareness-cum-Seminar on "Role of Atomic Energy & Nuclear Power in the Service of Mankind"

The seminar consisted of six lectures, one demonstration in Odia and Hindi Languages Scientific Programme of the event and one quiz competition.The first lecture was on परमाणु का विखंडन- देश की समृद्धि एवं विकास के लिए delivered by Shri. S. K. Malhotra, former Head, Public Awareness Division, DAE, Mumbai and now as Secretary, AEES, Mumbai. The second lecture was delivered in Odialanguage by Prof. Ajit Kumar Mohanty, Director, SINP, Kolkata on " Career opportunities in DAE Establishments". The third lecture was delivered by Dr. R. Acharya, Radiochemistry Division, BARC, Mumabi on "Research and Development Activities at BARC for Societal Benefits " in Odia language. The fourth lecture was delivered by Dr. DebakantaSamal, IOP, Bhubaneswar on "The Physics of Atomic Energy" in Odia language.

Highlights of the event

The seminar was inaugurated by Shri ParshuramDhada, M.L.A., Soro, District-Balasore, Odisha. The inaugural session was chaired by Prof. Sudhakar Panda, Director, IOP, Bhubaneswar in the presence of Prof. Ajit Kumar Mohanty, Director, SINP, Kolkatta as the Guest of Honour, Shri. S. K. Malhotra, Raja Ramanna Fellow & Secretary, AEES, Mumbai as the Chief Speaker and Shri B. K. Mohapatra, Principal, U. N. College, Soro as the Guest of Honour. Prof. B. R. Sekhar, Professor & Chairman, Organising Committee welcomed the gathering. Shri BhagabanBehera, Convener, Organizing Committee briefed about the seminar. Shri SrikantaSamal, HOD, Physics Department, U. N. College proposed the vote of thanks. A souvenir was released by the invited guests on this occasion. The seminar was attended by 157 students, 23 college teachers, 10 volunteers from different colleges, and 07 media people.

All the students & faculties were very much enthusiastic about the nuclear power. During the seminar, students raised various queries regarding, safety aspects of NPP environmental impact of radioactive discharge etc. After knowing the vast applications of radiation, the students were highly impressed. All the queries raised by students were suitably addressed during the session and they were able to understand & appreciate the measures being taken to make nuclear energy safe & environmentally benign.

7.1.2.Public Awareness conducted at GopabandhuVidyamandir,Po-SailoBadabil, Distt.- Cuttack on 23.10.2016.

To spread awareness on atomic energy & nuclear power among students, teachers, general public, and media persons, a special seminar-cum-workshop on "Atom in the service of Mankind" (in Odia language) was organized on 23.10.2016 at GopabandhuVidyamandir, L. B. Nagar, Po-SailoBadabil, Dist.- Cuttack, Odisha in association with IANCAS, C/o. BARC, Mumbai. The seminar was attended by 200 students from the school, 30 members of Old Students Association, GVM, L.B. Nagar and their family members, 20 villagers and 05 media people.

In the inauguration session Mr. Pradhan NiranajanPatanaik, Head Master, Gopabandhu Vidyamandir, Mr. Kalindi Ch. Behera, President Old Students Association, GVM, Mr. P. N. Acharay, Secretary, Old Students Association,

GVM, Mr. Somanath Acharya, Head Master, Jayadev M.E. School, Sri Chandan Kumar Behera, Head Master GVM , M.E. School were present. As a resource person Dr. Raghunath Acharya, RCD, BARC from IANCAS, Dr. Biswajit Mallick and Dr. K. C. Patra from IOP were present. In addition to this, all teaching and non-teaching staffs of GVM High School and M. E. School were present.

Dr. Raghunath Acharya delivered a talk on "Atom in the service of mankind" in Odia language. He briefed the history and activities carried out by Department of Atomic Energy for the welfare of the mankind through power presentation.

After the talk, questions on atoms, reactors, nuclear sciences, x-rays etc. were asked by the students and members of audience.

A quiz competition was also organized among the students, which was conducted by Dr. Acharya. The winners of the competition were awarded with prizes.

For enhancement of the knowledge, a demonstration on the measurement of radiation through detector was displayed by Dr. Mallick and Dr. Patra.

7.1.3.Public Awareness Programme conductedat Ekalavya Model Residential School, Mahasingi, Kandhamal, Odisha

An Awareness-cum-Workshop on "Nuclear Technologies for betterment of Tribals' Social Life" was organized at Ekalavya Model

Residential School (EMRS), Mahasingi situated in the district of Kandhamal of Odisha during 18th – 19th March, 2017 by IOP, Bhubaneswar with support from Department of Atomic Energy (DAE), co-ordinated by Shri Ranjit Kumar, Head, NCPW, DAE. The aim of the programme was to draw the awareness of students and teachers in remote areas towards the Nuclear Power as safe, economical, environmentally benign, long term source of electrical energy and to remove the misconceptions about radiation effect from their mind.

The workshop was attended by more than 500 participants from 12 different nearby schools and colleges, district government officials, educational & social activists, NGOs and media personnel.The program was inaugurated by Sri Reghu G., IAS, Collector-cum-District Magistrate, Kandhamal, Odisha and chaired by Prof. Sudhakar Panda, Director, IOP Bhubaneswar. Dr. Umasankari Kanan, Head, Reactor Physics Design Division, BARC, Mumbai was the Chief Speaker; Sri Ramesh Chandra Behera, OWS, Project Administrator, ITDA, Balliguda & Principal, EMRS, Mahasingi was the Guest of Honourfor the inaugural function. Sri Rushi Kumar Rath, Registrar & Chairman, Organising Committee welcomed the gathering and set the context of the event. Shri BhagabanBehera, Jt. Convener, Organizing Committee briefed about the purpose and aim of the programme, while Dr. Biswajit Mallick, Jt. Convener, proposed the vote of thanks.The first lecture was on "बिजलीउत्पादन और अन्य सामाजिक अनुप्रयोगों के लिए नाभिकीय ऊर्जा" (Nuclear energy for power generation and other societal applications) delivered byDr. UmasankariKanan, Head, Reactor Physics Design Division, BARC, Mumbai.

The second lecture was delivered by Dr. Smita Mule, SO-H, Technology Transfer & Collaboration Division, BARC, Mumbai on "(जनजातियों के सामाजिक जीवन की उन्नति में नाभिकीय प्रयोद्योगिकियाँ)"(Nuclear Technologies for Betterment of Tribals social life. The third lecture was delivered by Dr. VivekNageshYelgaonkar,Head, QA/QC, Industrial Safety and Isotope Application Services, Board of Radiation and Isotope Technology, BRIT/BARC, Mumbai on "समाजनिर्माण में विकिरण और आइसोटोप प्रद्योगिकी बोर्डकीभूमिका" (Role of Board of Radiation and Isotope Technology in Society Formation).The fourth lecture was delivered by Dr. DebakantaSamal, Reader–F, IOP, Bhubaneswar on "ପରମାଣୁ ଶକ୍ତିର ପଦାର୍ଥବିଜ୍ଞାନତତ୍ତ୍ୱ" (The Physics of Atomic Energy) in Odia language.The fifth lecture was delivered by Dr. S. N. Sarangi, SO, IOP, Bhubaneswar on "ନାଭିକୀୟ ପ୍ରବିଧି ଏବଂ ନାନୋବିଜ୍ଞାନ" (Nuclear Systems & Nano Science) in Odia language.The sixth lecture was delivered by Dr. SatyaprakashSahoo, Reader–F , IOP, Bhubaneswar on "ରାଷ୍ଟ୍ରନିର୍ମାଣରେ ପଦାର୍ଥ ବିଜ୍ଞାନ ପ୍ରତିଷ୍ଠାନ, ଭୁବନେଶ୍ୱରର ଯୋଗଦାନ" (Role of IOP, Bhubaneswar in the nation building) inOdia language.The seventh lecture was delivered by Dr. BiswajitMallick, SO–C , IOP, Bhubaneswar on "ସମାଜ ସେବାରେ ନାଭିକୀୟତ୍ୱରକ" (Nuclear Accelerator in the Service of Society) in Odia language.The eighth lecture was delivered by Mr. Atul Mishra, Health Physicist, IOP, Bhubaneswar on "परमाणु विकिरण जाँच और सुरक्षामापन"(Identification of Atomic Radiation and Safety Measures) in Hindi. He covered the source of radiation, effect of radiation and safety measures of radiation.The ninth lecture was delivered by Shri Rushi Kumar Rath, Registrar& Chairman, Organising Committee on

"Tribals' Scientific Knowledge" both in English &Odia languages.

The Valedictory session was conducted after the full pack programs on 19th March which was presided by Prof. Sudhakar Panda, Director, IOP, Bhubaneswar. Shri V. Kartikayan, IFS, District Forest Officer, Baliguda was the chief guest for the valedictory function. The other dignitaries present wereShri Rushi Kumar Rath, Registrar, IOP; Shri N. Pradhan, Sub-Collector, Baliguda; Shri Ramesh Chandra Behera, Project Administrator, ITDA, Baliguda as guest of honour of the function.A "Souvenir" was released by the guests on this occasion and distributed to all the students and teachers along with the participation certificates.

7.2 National Science Day

IOP has celebrated National Science Day - 2017 on 28th February, 2017 in the Institute with the following activities under the theme "Science and Technology for specially abled persons". An educational film based on the life of Sir C. V. Raman was shown. Another film related to Nuclear Science & Atomic Energy Technologies was also shown to the gathering before the inaugural session of the occasion.

The programme began with the welcome address by Dr. DebakantaSamal, Convener of the programme. He spoke about the importance of National Science Day Celebration and Sir C.V. Raman's contribution towards Science and Technology. Prof. Sudhakar Panda, Director inaugurated the function and gave inaugural address on "Science and Technologies for abled Persons". About 300 students and 28 teachers from different schools and colleges, 12 media people from different media houses, faculty members, scholars &staff members of the Institute participated in this programme.

The first lecture was delivered by Shri Ram Kishor Sharma, Assistant Director (Employment), Vocational Rehabilitation Centre for Handicapped, Ministry of Labour & Employment, Govt. of India, Bhubaneswar. He spoke on "Science and Technology for the Specially Abled Persons". He gavean interesting talk on different technologies used in rehabilitation of specially abled persons and also showed video clips on fitment aids/appliances such as tricycles, wheel chairs, hearing aids, walkers, crutches, surgical shoes, artificial limbs and callipers etc..

The second lecture was given by Prof. A. M. Srivastava, Institute of Physics, Bhubaneswar on "The Universe, Elementary Particles, and Dark Energy". He explained about the Big-Bang Theory of the Universe and emphasized on discovery of universe by scientist over hundreds of years. Starting from Galileo Galilee to the most recent Prof. Vera Rubin who discovered dark energy and dark matter. He further mentioned

that every topic related to the mysteries of the Big Bang theory and universe.

A total of 26 schools and colleges were participated in the science model competition, out of which, 03 schools were selected for awards. Others were given consollation prizes.

The evening function commenced the gracious presence of Dr. S. C. Jamir, His Excellence Governor of Odisha. Attending the event as Chief Guest, Dr. Jamir said "Investment in special education, establishment of centers of excellence, and application of knowledge in industrial and economic markets are essential in the current scenario. Science only thrives in a community which approaches different problems in the spirit of a logical enquiry. A diverse community is better able to generate new research methods, explanations, and ideas which can help science to shed new light on old problems ". The Governor expressed his happiness over this year's National Science Day celebrationas it was dedicated to speciallyabled persons and felicitated the winners of different competitions.

7.3 Night sky viewing session

Institute of Physics arranged following two nights sky watch programs for all the members of IOP and their families.

- Arrangements were made for observing the transit of Mercury across the Sun on 9thMay, 2016. A projection system was set up using the telescope to view the image of the Sun on a screen, clearly showing sunspots (during setup).
- Using two telescopes and a binocular, a night sky observation session was held on 13thMay, 2016 at the Institute during 7:30 P.M– 11.00P.M. Good viewing conditions permitted observations of Moon craters, Jupiter (its four moons and several bands were seen), Mars (grey shades of the surface were visible), and Saturn (very good view of its two rings, and two of its moons).
- Along with members of HBCSE, Mumbai, we conducted a night sky watch with telescopes and binoculars for the school students from diûerent parts of Odisha (from

10 P.M. to 3 A.M. on 20th Dec., 2016) at the "*Rtapalli Vidyapith*" school, Balipatana, Odisha. This was a part of the event organized by "*The Science Movement*" Organization, Bhubaneswar.

- Participated in the organization of the International Olympiad in Astronomy and Astrophysics (IOAA-2016), held in Bhubaneswar, 9-19 Dec. 2016 as Member of the Academic Committee of IOAA-2016.
- Participating in the preparation of the Indian Team for the International Olympiad in Astronomy and Astrophysics (IOAA-2017) to be held in Thailand (will be accompanying the Indian Team).

Visits of school students

The Institute regularly receives requests from various schools in Odisha and outside for visits to its Laboratory facilities which are arranged and managed under the Outreach Program. For this year also several such visits were organized.

Social outreach

Several Institute scholars as well as other members, through the organization Zaria, have been volunteering to teach children of the local Basti and are helping them to enroll in schools.

7.4 Implementation of Official Language

Institute is implementing the Official Language Policy of Govt. of India and ensuring compliance of Official Language as per policy of the Union.

During the year 2016-17, three meetings of the Official Language Implementation Committee were held under the chairmanship of Registrar. During the meetings progressive use of Hindi at the Institute was discussed and decisions were taken to increase use of Hindi in official work.

As a help literature, Institute brought out a Hindi book "Vyabaharika Rajbhasha Margadarshika" and distributed among the staff members.

Hindi Pakhwara was celebrated from 14th September to 28Th September, 2016 in the Institute. Various competitions were conducted during this occasion. Maximum staff members were participated in these competitions. On 29th September, 2016 prize distribution function was organized.

During the period of report, three staff members forPrangya training, one for Praveen training were nominated.

Hindi workshops were conducted in every quarter for officer/staff of the Institute in order to remove their hesitation in doing work in Hindi and enabled them to carry out day-to-day work in Hindi.

Joint Scientific Seminar in Hindi on " Role of Scientific and Technical Institutes in Economic Self-reliance " on 27th February, 2017 in the Institute.

7.5 The Women's Cell at IOP

The Women's Cell looks after the welfare of the Women members, visiting members and the workers of the Institute. It also facilitates redressal of issues and grievances concerning them. The Women's cell in IOP was constituted in

accordance with the mandate that it shall be the duty of the Employer 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 etc. by developing a conducive atmosphere on the campus, where women can work safely with dignity and without any Discrimination.

The main functions of the TWC (The Women Cell) at IOP are:

- Promotion of Gender amity : Providing information/consultation on gender amity to any student or members.
- Programmes concerning women's welfare: Bring out publications/posters on promoting gender amity and preventing gender discrimination and sexual harassment at work place.
- Documentation and Dissemination: Notice boards and the IOP web page provide everyone with names and phone extensions of the TWC members.
- Deal with Cases of Gender Discrimination/ Sexual Harassment: Committee looks into complaint of gender discrimination/sexual harassment and makes an inquiry into the case. Committee provides support service to the victimized and recommends an early action to the Director to ensure termination of the harassment with immediate effect. It also submits a report to the Director, recommending appropriate punitive action against the accused found guilty.

The constitution of the IOP women's cell is:

Prof. ShikhaVarma, IOP:	Chairperson
Prof. B.R. Sekhar :	Member
Dr. Debsmita P. Alone, NISER :	Member
Dr. RooplekhaKhuntia, NISER :	Member
Smt. NageswariMajhi, IOP :	Member

Two Special Talks were organized by IOP Women-Cell. These talks were delivered by Advocate (Ms.) Rama Sarode, Socio-Legal Consultant and Trainer, Secretary- Sahyog Trust, Pune in June, 2016.

In the first talk titled "*Journey of Laws related to Women*", Ms. Sarode discussed that how even after more than 60 years of ensuring Right to Equality, we are still struggling to bring gender equality in our society. This struggle for equality has seen the passing of laws to protect the rights of the women. Each legislation has a history of struggle and most women related laws are response to a grave violation of women's right. This session covered the struggles, challenges and making of laws.

In the second talk titled "*Laws against Sexual Harassment of women at workplace*",Ms. Sarode discussed such laws with many examples. She especially mentioned the case of Bhaveri Devi which in the 90s shook India and brought to discussion the security of women at workplace. She elaborated on the Vishakha guidelines that have been given by the Supreme Court to prevent sexual harassment of women at workplaces. However, their implementation could only be strengthened after the passing of Sexual Harassment of Women at Workplace (Prevention, Prohibition and Redressal) Act in 2013. The talk extensively discussed the provisions of this law and the experiences of its implementation.

7.6 Implementation of Swachh Bharat Mission

As per directives of the Department of Atomic Energy, Govt. of India,Swachh Bharat Abhiyan has been launched at this Institute. The Swachh Bharat Mission (SBM) program started in the Institute on 2nd October, 2014. Director of IOP, staff members and the scholars voluntarily participated in a cleanliness drive, covering the office rooms, laboratories, workshops, hostels, canteen, gardens, and residential colony of the campus. Periodic cleaniliness is being taken up by the staff members and scholars on regular basis every month. On 18th August, 2016, a Comittee consisting of the Director, the Registrar, the Administrative Office and the Junior Admnistrative Officer made a periodic inspection to the above.

7.7 Sports and Cultural Activities

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 members physically fit. To carry out different sports and cultural activities a committee was formed in the IOP Employees Welfare Society (IOPEWS).

The members of the society are: Dr. Suresh Kumar Patra (President), Mr. BhagabanBehera (Secretary), Dr. SatyaprakashSahoo, Mrs. A.K. Kujur , Mr. PriyabrataPatra(Treasurer), Mr. Sahadev Jena (Convener Cultural), Mr. SreyanshSekhar Dave, Mr. BrundabanMohanty and Mr. Balakrushna Dash (Convener Sports).

Every year all members involve themselves in different sports and cultural activities like Table Tenis, Carrom, Volleyball, Bridge, Kabaddi, Badminton etc. along with arranging of SPICMACAY programs throughout the year.

Following are the different activities conducted during the year 2016-17:

- A Football match was conducted on 15th August, 2016. This was a friendly match played between Director's Team (Faculties, Doctorial Scholars) and Registrar's Team (Staffs) of the Institute. Match was draw. Dr. Saptarshi Mandal was the captain of the Champion team and Mr. BrundabanMohanty was the captain of the runner's up team. Around 100 spectators were present to enjoy the football match.
- A friendly Cricket match was conducted on the occasion of 26th January, 2017. This match was played between Director's Team (Faculties & Doctorial Scolars) and Registrar's Team (Staffs). Mr. Shreyans Shankar Dave was the captain of Director's Team and Mr. Pramod Kumar Senapati was the captain of Registrar's Team. Registrar's Team won the match. It was a very interesting match. Around 90-viewers joined and made the event successful.
- Social activities generate a lot of interest and pleasure among staffs and their dependents. For this purpose a program was organized

on 14th November, 2016 being celebrated as the children's day throughout the country. On that day the campus children performed various activities like song, dance, and playing instruments on the stage. Participants from the age of 5-years to 16-years performed their art in front of 150 viewers in the IOP auditorium.

The photos of Children's Day program

- Institute also organized the Annual Sports and Cultural Meet in the month of August, 2016. These events started on 08.08.2016 and got completed on 04.09.2016. The total number of events were 17. Around 60 staff members participated in gents group, 30

family members participated in the female 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 with medals in the Annual day celebration.

- In the year 2016-17, Dr.BiswajitMallick, Mr. SrikantMishra and Mr. Chandra Mohan Hanshdah were also selected to go to Kakrapar, Gujurat to competein the final round matches of Swimming.
- On the occasion of Annual day a prize giving ceremony was conducted followed by a cultural progreamme, drama, performed by IOP members. The Title of drama was "Guru Dakshina".

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. Snehadri B. Ota**
   Reader - F
   Condensed Matter Physics (Experiment)
9. **Prof. Sudipta Mukherji**
   Professor
   High Energy Physics (Theory)
10. **Prof. Suresh K. Patra**
    Professor
    Nuclear Physics (Theory)
11. **Prof. Tapobrata Som**
    Professor
    Condensed Matter Physics (Experiment)
12. **Prof. Goutam Tripathy**
    Reader-F
    Condensed Matter Physics (Theory)
13. **Prof. Pradip Kumar Sahu**
    Associate Professor
    Nuclear Physics (Theory)
14. **Prof. Dinesh Topwal**
    Reader - F
    Condensed Matter Physics (Experiment)
15. **Prof. Amitabh Virmani**
    Reader - F
    High Energy Physics (Theory)
16. **Prof. Sanjib Kumar Agarwalla**
    Reader - F
    High Energy Physics (Theory)
17. **Prof. Arijit Saha**
    Reader - F
    Condensed Matter Physics (Theory)

18. **Prof. Saptarshi Mandal**
    Reader - F
    Condensed Matter Physics (Theory)
19. **Prof. Satyaprakash Sahoo**
    Reader - F
    Condensed Matter Physics (Expt.)
20. **Prof. Aruna Kumar Nayak**
    Reader-F
    High Energy Physics (Experiment)
21. **Prof. Debashis Chaudhuri**
    Reader - F
    Condensed Matter Physics (Theory)
22. **Prof. Shamik Banerjee**
    Reader - F
    High Energy Physics (Theory)
23. **Prof. Debakanta Samal**
    Reader - F
    Condensed Matter Physics (Expt.)
24. **Prof. Debottam Das**
    Reader - F
    High Energy Physics (Theory)
25. **Prof. M. M. Mitra**
    Reader - F
    High Energy Physics (Theory)
26. **Prof. Kirtiman Ghosh**
    Reader - F
    High Energy Physics (Theory)

8.2. Post-Doctoral Fellows

1. Chirashree Lahiri *(upto 2nd Nov, 2016)*
2. Somnath De *(upto 28th September, 2016)*
3. Bipul Rakshit *(upto 30th Nov., 2016)*
4. Chandan Giri *(upto 12th March, 2017)*
5. P. Dash *(upto31st March, 2017)*
6. Pranati K. Rath *(upto 26th Aug, 2016)*
7. Arnab Dasgupta
8. Paramita Dutta
9. T. Arun
10. D. K. Ray *(upto 26th October, 2016)*
11. Maguni Mahakhud
12. Ravi Kumar Bomali
13. Md. Younus
14. Shidharth Shankar Ram
15. M. Muneeswaran
16. S. Bhattacharjee
17. Haripriya Rath
18. Safiul A. Mollick *(up to Dec, 2016)*
19. Shidharth S. Ram *(up to Dec, 2016)*

8.3. Research Associate

1. Sujit K. Choudhury
2. Subhashis Rana
3. Tanmoy Pal
4. Anjan Bhukta
5. Arnab Ghosh
6. Himanshu Lohani
7. Mohit Kumar

8.4. Doctoral Scholars

1. Shailesh Kumar Singh
2. Shailik Ram Joshi
3. Sk. Sazim
4. Subhadip Ghosh
5. Arpan Das
6. Sumit Nandi

7. Soumyabrata Chatterjee
8. Subrata Kumar Biswal
9. Bidisha Chakrabarty
10. Priyo Shankar Pal
11. Puspendu Guha
12. Sabya Sachi Chatterjee
13. Shreyansh Shankar Dave
14. Sudipta Mahana
15. Arpan Das *(Junior)*
26. Ashis Kumar Manna
17. Bharat Kumar
18. Chandan Datta
19. Debashis Saha
20. Mahesh Saini
21. Paramita Maiti
22. Pronoy Nandi
23. Ranveer Singh
24. Amit Kumar
25. Biswajit Das
26. Ganesh Chandra Paul
27. Partha Paul
28. Pratik Roy
29. Sujay Shil
30. Vijigiri Vikas
31. Alapan Dutta
32. Atanu Maity
33. Amir Shee
34. Dibyendu Rana
35. Dilruba Hasina
36. Mukaddar Sk.
37. Amina Katun (INO Proj. Student)

8.5. Administration

Prof. B. R. Sekhar, Registrar *(upto 2nd Oct., 2016).*

Shri R. K. Rath, Registrar *(From 3rd Oct., 2016).*

(i) Director's Office:

1. Sk. Kefaytulla
2. Raja Kumari Patra*(upto 28th February, 2017)*
3. Rajesh Mohapatra
4. Rajan Biswal
5. Sudhakar Pradhan

(ii) Registrar's Office

1. Bira Kishore Mishra
2. Abhimanyu Behera

(iii) Establishment

1. M.V. Vanjeeswaran
2. J. C. Patnaik *(upto 31st August, 2016)*
3. Sahadev Jena
4. Bhagaban Behera
5. Baula Tudu
6. Samarendra Das
7. Abhisek Maharik
8. Ghanashyam Pradhan

(iv) Stores & Transport

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

(v) EPABX

1. Arakhita Sahoo
2. Ghanashyam Naik

(vi) Despatch

1. Krushna Chandra Sahoo

(viii)Accounts

1. Ranjan Kumar Nayak
2. Pravat Kumar Bal
3. Jitendra Kumar Mishra
4. Bhaskara Mishra
5. Prativa Choudhury
6. Soubhagya Laxmi Das
7. Aviram Sahoo
8. Priyabrata Patra
9. Lipika Sahoo
10. Chandramani Naik
11. Bansidhar Panigrahi

(ix) Maintenance

1. Arun Kanta Dash
2. Subhabrata Tripathy
4. Debaraj Bhuyan
5. Bansidhar Behera
6. Brundaban Mohanty
7. Deba Prasad Nanda
8. Rama Chandra Murmu
9. Naba Kishore Jhankar
10. Baikuntha Nath Barik *(upto 30th Nov., 2016)*
11. Purna Ch. Maharana
12. Sajendra Muduli
13. Pabani Bastia
14. Rabi Narayan Mishra
15. Umesh Ch. Pradhan
16. Gandharba Behera
17. Biswa Ranjan Behera
18. Kapila Pradhan
19. Martin Pradhan
20. Chandra Mohan Hansdah

(x) Estate Management

1. Saroj Kumar Jena.
2. Dhobei Behera *(upto 31st August, 2016)*
3. Gangadhar Hembram
4. Tikan Kumar Parida
5. Kailash Chandra Naik *(upto 30th Oct., 2016)*
6. Banamali Pradhan
7. Gokuli Charan Dash
8. Biswanath Swain
9. Bijaya Kumar Swain
10. Bijaya Kumar Das
11. Babuli Naik
12. Pradip Kumar Naik
13. Meena Dei
14. Sanatan Pradhan
15. Bhaskara Mallick
16. Kulamani Ojha
17. Pitabas Barik
18. Dhoba Naik
19. Charan Bhoi
20. Jatindra Nath Bastia
21. Basanta Kumar Naik
22. Daitari Das

(xi) Library

1. Basudev Mohanty (From 1st Dec, 2016)
2. Dillip Kumar Chakraborty
3. Ajita Kumari Kujur
4. Rama Chandra Hansdah
5. Rabaneswar Naik
6. Kisan Kumar Sahoo
7. Kailash Chandra Jena

(xii) Computer Centre

1. M. Shidhabatti *(From 1st July, 2016)*
2. Nageswari Majhi

(xiii) 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

(xiv) Workshop

1. Ramakanta Nayak
2. Rabi Narayan Naik

8.6 List of new faculty members

Dr. Debottam Das, Reader-F
DoJ:04.01.2017

Dr.(Mrs.) Manimala Mitra, Reader-F
DoJ: 23. 01. 2017

Dr. Kirtiman Ghosh, Reader-F
DoJ:02.03.2017

8.7 List of new administrative staff

Shri Rushi Kumar Rath
DoJ:03.10.2016 as Registrar

Shri Keshaba Chandra Dakua
Doj:09.11.2016 as MTS – A

Shri Ramesh Kumar Patnaik
DoJ:11.11.2016 as MTS – A

Dr. Basudev Mohanty
DoJ:01.12.2016 as Librarian

Shri Jyoti Ranjan Behera, SA/B
DoJ : 27.01.2017

Shri Makrand Siddhabhatti, SO-C (Sys. Mngr)
DoJ: 01.07.2016

8.8 List of retired members

Shri Jaya Chandra Patnaik
Designation:Jr. Admn Officer
DoJ:10.06.1982, DoR:31.08.2016

Shri Dhobei Behera
Designation:Tradesman-A
DoJ:21.08.1981, DoR:31.08.2016

Shri Kailash Chandra Naik
Designation: MTS/B
DoJ: 03.07.1990, DoR: 31.10.2016

Shri Baikuntha Nath Barik
Designation: Tradesman - G
DoJ: 29.05.1982, DoR: 30.11.2016

Smt. Raja Kumari Patra
Designation: Trades woman
DoJ : 11.03.1976, DoR : 28.02.2017

Shri Sanatan Das
Designation: Tradesman-A
DoJ: 21.05.1982, Do R: 31.03.2017

परीक्षित लेखा विवरण

AUDITED STATEMENT OF ACCOUNTS
2016-17

भौतिकी संस्थान
INSTITUTE OF PHYSICS
भुवनेश्वर, ओडिशा
BHUBANESWAR, ODISHA

लालदास एंड कंपनी / LALDASH & CO.
सनदी लेखाकारों / CHARTERED ACCOUNTANTS
प्लॉट नं. 1882 (दूसरी मंजिल) / PLOT NO.1882 (2ND FLOOR)
नीलकंठ नगर / NILAKANTHA NAGAR
यूनिट-8, नयापली / UNIT-8, NAYAPALLI
भुवनेश्वर / BHUBANESWAR – 751 012
दूरभाष / PHONE: (0674) 2561638

Contents

Laldash & Co.
CHARTERED ACCOUNTANTS

INDEPENDENT AUDITOR'S REPORT

To,
The Director
The Institute of Physics
Bhubaneswar

We have audited the accompanying financial statements of **INSTITUTE OF PHYSICS** which comprises the Balance Sheet as **at 31st March 2017** and the Statement of Income and Expenditure and Statement of receipts 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 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 procedures to obtain audit evidence about the amounts and disclosures in the financial statements. The procedure selected depend on the auditor's judgment, including the assessment of the risks of material misstatement of the financial statements, whether due to fraud or error.In making those risk assessments; the auditor considers internal controls relevant to the Entity's preparation and fair presentation of the financial statements in order to design audit procedures that are appropriate inthe circumstances. An audit also includes evaluating the appropriateness of accounting policies used and the reasonableness of the accounting estimates

LAL DASH & CO. Chartered Accountants BBSR

H.O - Plot No.: 1882 (IInd Floor), Nilakantha Nagar, Unit-8, Nayapalli, Bhubaneswar -751 012
☎ : (0674) 2561638, Tele/Fax : (0674) 2562638, Mob.: 9937020638, E: dashbijaya62@hotmail.com

made by management, as well as evaluating theoverall 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 AS 6 for depreciation have not been followed. There was no fixed assets register to verify the individual assets residual value. Depreciation has been charged on gross block at the end of the year on SLM methodirrespective of the fact that individual old assets may have been depreciated in full.E-journals have been capitalized as tangible assets and depreciated for whole year. E-journals are paid on calendar yearly basis but the whole years e-journals have been capitalized thus contravening the provisions of AS10 and AS-6.The depreciation on assets purchased during the year was also charges for full year instead of proportionate basis from date put to use.
2. IAS 12 on Accounting of Government grants has not been followed. The grants have been recognized on realization basis. Capital grants are recognized as capital fund and shown as liability.
3. TDS not deducted under section 194J in case of engagement of persons as consultants and the expenses of salary paid to them are directly booked to maintenance expenses. The same are treated as salary by the institute in computation of Income tax for TDS. Expenses booked under computer maintenance and civil maintenance.

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 were available in the file. Lease records in respect of 6.130 acres was available. As per management the land records of the Institute for 47.32 Acre have been updated in the name of IOP and mutaion is still in process.
2. Balances of advances and liabilities recognized from third Parties are subject to confirmation.

We are not qualifying our report on the above points.

Based on 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 inIndia:

a. In the case of the Balance Sheet, of the state of affairs of the Institute as at March 31, 2017;
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 Receipts 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 thebest 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 dealt with by this report, are in agreement with the books of accounts.

Date: -28/8/2017
Place:- Bhubaneswar

LAL DASH & CO. • Chartered Accountants • BBSR

For Laldash and CO.
Chartered Accountants
(Firm Reg No 311147E)

CA A.K.Samantaray,FCA
PARTNER
Membership No.063226

INSTITUTE OF PHYSICS
BHUBANESWAR

ANNEXURE TO THE AUDIT REPORT (REFERED TO IN OUR REPORT ON EVEN DATE)

AUDIT OBSERVATIONS ON THE ACCOUNTS OF INSTITUTE OF PHYSICS FOR THE FINANCIAL YEAR 2016-17

1. **Maintenance of books of accounts:**
   - i) The following manual books of accounts are maintained in the year 2016-17:
     - a) Cash cum bank Book
     - b) Cheque issue register
     - c) Staff advance register
     - d) Security deposit register
     - e) TDS register
   - ii) The institute uses a wings accounting package also which is updated every 15 days. The journilasation of transactions were started since April 2016 in the wings package, however the manual cashbook is still maintained on old format.

2. **Cash and Bank:**
   - a) Institute didn't have any guidelines for holding minimum cash balance. In many instances the institute has had maintained cash balance above Rs. 10000.00. Few cases are cited at annexure-1.
   - b) In some cases the institute has paid cash above Rs. 20000 to visiting scientists/
   - c) Employees. Instances given at Annexure-2.
   - d) The Institute had operated 5 Nos. of Bank accounts. All banks have been reconciled and the bank reconciliation statements are given at Annexure-3.
     - i) However from the bank reconciliations it was observed that in case of IOB Non Plan account RS. 20267.00 was debited on 05.10.2016 in the account but the same not accounted for in the cash book yet. The same amount was debited to the Plan account of IOB in cash. The difference was yet to be effected although its 6 months old. The same appears in the banks reconciliation statement of IOP plan account as well as "cheques issued but not presented for payment."
     - ii) Balance confirmation certificates from banks were not available for verification. Bank statements were relied upon for balances.

3. **Non Receipt of journals:** The institute subscribes for journals for its library. Journals paid for but not received as on 31.03.2017 was Rs.45,640.00. The same if not received may be recovered from the suppliers.

4. **Others:**
   - **a)** Expiry of rent agreement with Bank: There is an Indian overseas bank operating in the campus on rent for 200 sqr. Mtr. of building. The agreement has expired since 30.11.2012. Rate charged still the same at Rs 12500 per month.

b) Electricity Charges: It was observed that electricity charges paid by the institute during the previous years include a portion of NISER operating from IOP campus. The proportionate electricity charges may be recovered from NISER. It was stated in the reply of the management in earlier years that the amount would be recovered from the assets to be left over by NISER after shifting, however no such recovery made although NISER has already left the IOP Campus.

c) Advances to staff unadjusted for more than 3 months were found in few cases. The same should be adjusted/recovered at an earliest. Details as under:

Sl No	Date	Name	Purpose	Amount(Rs.)
1.	28.10.2016	Purna Moharana	Medical Advance	66308.00
2.	23.11.2016	Rajan Biswal	Medical Advance	12842.00
3.	12-01-2009	Hari Naik	Medical Advance	1000.00
4.	09.09.2016	Goutam Tripathy	CMQI	5000.00
5.	09/05/2016	Tabobrata Som	Purchase Adv.	5000.00

d) Loans outstanding for more than two years: The following staff loans are outstanding for more than two years.

Sl No	Date	Name	Purpose	Amount(Rs.)
1.	2007-08	J.K.Mishra	Computer Loan	6400.00
2.	2004-05	A.M.Srivastava	Motor Car Loan	26000.00
3.	2005-06	Bhaskar Mallik	Housing Loan	16000.00

e) There was sale of fixed Assets to the tune of Rs. 6700.00. However the same was shown under Misc. Income. The assets sold have not been deducted from the value of assets and accumulated depreciation.

For LAL DASH & CO
Chartered Accountants
28/12
A.K. SAMANTARAY FCA
PARTNER
M.No.063226

LAL DASH & CO. Chartered Accountants BBSR

Institute Of Physics, Bhubaneswar

Instances of Cash Balance Above Rs. 10000 **Annexure-1**

Sl No	Date	Balance (Rs.)
1	18.04.2016	32335.65
2	02.05.2016	43093.65
3	03.05.2016	121593.65
4	04.05.2016	66789.65
5	10.05.2016	71908.65
6	29.06.2016	26830.65
7	30.06.2016	44572.65
8	05.07.2016	34850.65
9	12.07.2016	55724.65
10	02.08.2016	47189.65
11	29.09.2016	90464.65
12	07.10.2016	22111.65
13	19.10.201	42963.65
14	24.10.2016	54764.65
15	04.11.2016	22636.65
16	14.12.2016	20342.65
17	16.12.2016	38402.65
18	10.01.2017	28348.65
19	30.01.2017	25629.65
20	06.02.2017	33287.65
21	28.02.2017	36844.65
22	02.03.2017	36844.65
23	06.03.2017	33596.65
24	17.03.2017	33596.65
25	23.03.2017	32971.65
26	31.03.2017	31621.65

Institute Of Physics, Bhubaneswar
Instances of Cash payments Above Rs. 20000.00

Annexur-2

Date	Particulars	Voucher No	Amount(Rs.)
28.02.2017	Adv. Paid to Bhagawan Behera For awards to winners on Science day	P-2037	40000
28.02.2017	Adv. Paid to Bhagawan Behera For Miscellaneous expenditure on Science day	P-2038	25000
17.03.2017	Amount paid to Bhagawan Behera for Awareness Programme	P-2166	40000
29.07.2016	Honorarium paid to Prof. A DAS , USA	P-834	70000
01.09.2016	Amount paid to Pratik Roy for arrangement for Alumini day	P-1023	43800
08.08.2016	Amount paid to IOP guest house towards cost of tea	P-863	30357
28.07.2016	Amount paid to Arti Deshmukhya towards TA	P-823	21758
18.07.2016	Amount paid to J K Mishra towards lunch arrangement for ATI Programme	P-744	70000
18.07.2016	Amount paid to Bhagawan Behera towards arrangement for ATI Programme	P-745	25000
30.06.2016	Amount paid to Ashok das towards Honorarium	P-671	72258
30.05.2016	Amount paid to Arijit saha towards working lunch	P-373	45000
27.10.2016	Amount paid to Kartikeswar Bengra towards TA	P-1347	25000

ANNEXURE-3

Reconcilation of S.B.A/c. No.316 of Institute of Physics, Bhubaneswar maintained in Union Bank of India, Chandrasekharpur Branch as on 31.03.2017

	Closing Balance as per Cash Book		-	119273.62
	ADD:			
#	Credited by bank, but not shown in Cash Book	0.00		
#	Cheque issued, but not presented for payment (LIST-A)	4822751.00	-	4822751.00
				4942024.62
	LESS:			
#	Cheque/DD received, but not credited in Bank (LIST-B)	0.00		
#	Dedited by bank, but not shown in Cash Book	15.00		
#	Closing balance in Bank (Flexi Deposit A/c.)	49732.67		49747.67
				49747.67
	Closing Balance as per Bank Statement			4892276.95

L.A. DASH & CO. BBSR Chartered Accountants

ANNEXURE-3

UNION BANK OF INDIA (NON-PLAN)

RECONCILLIATION AS ON 31.03.2017

Cheque issued, but not presented for payment (LIST-A)					
Cheque No.	Date	Amount	Cheque No.	Date	Amount
036122	31-03-2017	7874.00		B/F.	156398.00
036123	31-03-2017	28511.00	036129	31-03-2017	7143.00
036124	31-03-2017	15410.00	036130	31-03-2017	1835.00
036125	31-03-2017	6000.00	036131	31-03-2017	1725.00
036126	31-03-2017	48630.00	036132	31-03-2017	564.00
036127	31-03-2017	40523.00	036133	31-03-2017	4655086.00
036128	31-03-2017	9450.00			
	Total C/F	156398.00		Grand Total :	4822751.00

Cheque/DD received, but not yet credited in Bank (LIST-B)					
Ref.	Date	Amount	Ref.	Date	Amount
				B/F.	0.00
	Total C/F	0.00		Grand Total :	0.00

Credited by Bank, but not entered in Cash Book (LIST-C)					
Ref.	Date	Amount	Ref.	Date	Amount
				B/F.	0.00
	Total C/F	0.00		Grand Total :	0.00

ANNEXURE-3

Reconcilation of S.B.A/c. No.14746 of Institute of Physics, Bhubaneswar maintained in Union Bank of India, Chandrasekharpur Branch as on 31.03.2017

	Closing Balance as per Cash Book		4793591.50
	ADD:		
#	Credited by bank, but not shown in Cash Book	0.00	
#	Cheque issued, but not presented for payment	419322.00	419322.00
			5212913.50
	LESS:		
#	Debited by bank, but not shown in Cash Book	0.00	
			0.00
	Closing Balance as per Bank Statement		5212913.50

LAL DASH & CO. BBSR Chartered Accountants

ANNEXURE-

UNION BANK OF INDIA (PLAN)

RECONCILIATION AS ON 31.03.2017

Cheque issued, but not presented for payment

Cheque No.	Date	Amount	Cheque No.	Date	Amount
025288	15-03-2017	2400.00		B/F.	419322.00
025291	31-03-2017	400486.00			
025292	31-03-2017	3256.00			
025293	31-03-2017	13180.00			
	Total C/F	419322.00		Grand Total :	419322.00

Debited by Bank, but not entered in Cash Book

Ref.	Date	Amount	Ref.	Date	Amount
				B/F.	0.00
	Total C/F	0.00		Grand Total :	0.00

Credit details shown in Bank, but not shown in Cash Book

Ref.	Date	Amount	Ref.	Date	Amount
				B/F.	0.00
	Total C/F	0.00		Grand Total :	0.00

ANNEXURE-3

Reconcilation of S.B.A/c. No.10917 of Institute of Physics, Bhubaneswar maintained in Indian Overseas Bank, Chandrasekharpur Branch as on 31.03.2017

	Closing Balance as per Cash Book		-	45403617.22
	ADD:			
#	Cheque issued, but not presented for payment (List-C)	10278468.00		
#	Earmarked/Blocked by bank (List-B)	0.00		
#	Credited by Bank, but not in Cash Book (List-E)	0.00	-	10278468.00
				55682085.22
	LESS:			
#	Debited by Bank, but not in Cash Book (List-A)	20267.00		
#	Cheque/DD deposited, but not credited by Bank (List-D)	44430148.79	-	44450415.79
	Closing Balance as per Bank Statement			11231669.43

LAL DASH & CO. BBSR Chartered Accountants

ANNEXURE-3

INDIAN OVERSEAS BANK, CHANDRASEKHARPUR (Non-Plan)

RECONCILIATION AS ON 31.03.2017

LIST-A

Debit details shown in Bank, but not shown in Cash Book

Reference	Date	Amount	Reference	Date	Amount
Scholar	10/5/2016	20267.00		B/F.	20267.00
	Total C/F	20267.00		Grand Total :	20267.00

LIST-B

Earmarked/Blocked by bank, but not reflected in Bank Ledger

Chq.No.	Date	Amount	Chq.No.	Date	Amount
				B/F.	0.00
	Total C/F	0.00		Grand Total :	0.00

LIST-C

Cheque issued, but not presented for payment

Chq.No.	Date	Amount	Chq.No.	Date	Amount
873421	3/21/2017	15000.00		B/F.	2937001.00
873422	3/21/2017	5342.00	873431	3/31/2017	6043054.00
873423	3/21/2017	100.00	873432	3/31/2017	1237280.00
873424	3/21/2017	7656.00	873613	3/31/2017	61133.00
873430	3/31/2017	2908903.00			
	Total C/F	2937001.00		Grand Total :	10278468.00

LIST-D

Cheque/DD received & deposited, but not yet credited by Bank

Reference	Date	Amount	Reference	Date	Amount
NEFT	31-03-2017	40000000.00		B/F.	44230782.21
PKSahu	31-03-2017	5000.00	873963	3/31/2017	185201.58
SKPatra	31-03-2017	16720.00	132107	3/31/2017	3463.00
SKPatra	3/31/2017	3256.00	67470	3/31/2017	10702.00
873962	3/31/2017	4205806.21			
	Total C/F	44230782.21		Grand Total :	44430148.79

LIST-E

Credit details shown in Bank, but not shown in Cash Book

Reference	Date	Amount	Reference	Date	Amount
				B/F.	0.00
	Total C/F	0.00		Grand Total :	0.00

L.K. DASH & CO. Chartered Accountants BBSR

ANNEXURE-3

Reconcilation of S.B.A/c. No.16916 of Institute of Physics, Bhubaneswar maintained in Indian Overseas Bank, Chandrasekharpur Branch as on 31.03.2017

	Closing Balance as per Cash Book		-	14098177.36
	ADD:			
#	Cheque issued, but not presented for payment (List-B)	10097576.29		
#	Credited by Bank, but not in Cash Book (List-D)	20267.00	-	10117843.29
				24216020.65
	LESS:			
#	Debited by Bank, but not in Cash Book (List-A)	0.00		
#	Cheque/DD deposited, but not credited by Bank (List-C)	61133.00	-	61133.00
	Closing Balance as per Bank Statement			24154887.65

ANNEXURE-3

INDIAN OVERSEAS BANK, CHANDRASEKHARPUR (PLAN)

RECONCILIATION AS ON 31.03.2017

LIST-A

Debit details shown in Bank, but not shown in Cash Book

Reference	Date	Amount	Reference	Date	Amount
				B/F.	0.00
	Total C/F	0.00		Grand Total :	0.00

LIST-B

Cheque issued, but not presented for payment

Chq.No.	Date	Amount	Chq.No.	Date	Amount
Dr.29/3/17	31-03-2017	276106.50		B/F.	2484118.50
873989	31-03-2017	90054.00	873990	31-03-2017	2886000.00
873991	31-03-2017	402044.00	873988	31-03-2017	114450.00
873992	31-03-2017	50641.00	873986	31-03-2017	222000.00
873993	31-03-2017	1624579.00	873962	31-03-2017	4205806.21
873994	31-03-2017	40694.00	873963	31-03-2017	185201.58
	Total C/F	2484118.50		Grand Total :	10097576.29

LIST-C

Cheque/DD received & deposited, but not yet credited by Bank

Reference	Date	Amount	Reference	Date	Amount
873613	31-03-2017	61133.00		B/F.	61133.00
	Total C/F	61133.00		Grand Total :	61133.00

LIST-D

Credit details shown in Bank, but not shown in Cash Book

Reference	Date	Amount	Reference	Date	Amount
F'ship	9/30/2016	20267.00		B/F.	20267.00
	Total C/F	20267.00		Grand Total :	20267.00

LAL DASH & CO. Chartered Accountants BBSR

ANNEXURE-3

Reconcilation of Current A/c. No.10057860171 of Institute of Physics, Bhubaneswar maintained in State Bank of India, RRL Campus Branch as on 31.03.2017

1. Closing Balance as per Cash Book	-	21481711.85
ADD: Cheque issued, but not presented (List-A)	-	9579304.00
ADD: Credited by Bank, but not in Cash Book (List-B)	-	0.00
Sub-Total:		**31061015.85**
LESS: Debited by bank		0.00
2. Closing Balance as per Bank Statement		31061015.85

ANNEXURE-3

STATE BANK OF INDIA, RRL CAMPUS BRANCH

RECONCILIATION AS ON 31.03.2017

LIST-A

Cheque issued, but not presented for payment

Chq.No.	Date	Amount	Chq.No.	Date	Amount
805399	31-03-2017	286402.00		**B/F.**	**7906665.00**
805391	31-03-2017	4000.00	805394	31-03-2017	1200000.00
805393	31-03-2017	1552350.00	805389	31-03-2017	57400.00
805390	31-03-2017	1956.00	805402	31-03-2017	21510.00
805395	31-03-2017	28800.00	805388	31-03-2017	11790.00
805396	31-03-2017	130000.00	805392	31-03-2017	184724.00
805397	31-03-2017	28800.00	805403	31-03-2017	5100.00
808385	31-03-2017	5871345.00	805402	31-03-2017	192115.00
805387	31-03-2017	3012.00			
	Total C/F	7906665.00		**Grand Total :**	**9579304.00**

LIST-B

Credited by Bank, but not reflected in Cash Book

Chq.No.	Date	Amount	Chq.No.	Date	Amount
				B/F.	**0.00**
	Total C/F	0.00		**Grand Total :**	**0.00**

LIST-C

Debited by Bank, but not reflected in Cash Book

Chq.No.	Date	Amount	Chq.No.	Date	Amount
	Total C/F	0.00		**Grand Total :**	**0.00**

LAL DASH & CO. BBSR Chartered Accountants

INSTITUTE OF PHYSICS, BHUBANESWAR

BALANCE SHEET AS AT 31ST MARCH 2017

(Amount - Rs.)

CORPUS/ CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year
CORPUS/ CAPITAL FUND	1	67,45,86,852	70,68,32,175
RESERVES AND SURPLUS	2	-	-
EARMARKED/ ENDOWMENT FUNDS	3	2,11,196	2,72,697
SECURED LOANS AND BORROWINGS	4	-	-
UNSECURED LOANS AND BORROWINGS	5	-	-
DEFFERED CREDIT LIABILITIES	6	-	-
CURRENT LIABILITIES AND PROVISIONS	7	17,97,42,611	12,56,90,641
TOTAL		**85,45,40,659**	**83,27,95,513**
ASSETS			
FIXED ASSETS	8	74,35,59,573	72,72,81,742
INVESTMENTS FROM EARMARKED/ ENDOWMENT FUNDS	9	-	-
INVESTMENTS OTHERS	10	-	-
CURRENT ASSETS, LOANS, ADVANCES ETC.	11	11,09,81,086	10,55,13,771
TOTAL		**85,45,40,659**	**83,27,95,513**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

In terms of our report of even date annexed

For LAL DASH & CO
Chartered Accountants

A.K. SAMANTARAY FCA)
PARTNER
M.No.063226

Place : Bhubaneswar
Date : 28-08-2017

लेखा अधिकारी/ACCOUNTS OFFICER
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

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 2017

(Amount - Rs.)

INCOME	Schedule	Current Year	Previous Year
Income from sale or services	12	-	-
Grants/ Subsidies	13	371,059,000	358,400,000
Fees/ Subscriptions	14	-	-
Income from investments	15	-	-
Income from royalty, Publication etc	16	-	-
Interest Earned	17	3,256,571	2,521,772
Other Income	18	2,064,842	1,677,445
Increase decrease in stock of finised goods/ WIP	19	-	-
TOTAL (A)		**376,380,413**	**362,599,217**
EXPENDITURE			
Establishment Expenses	20	213,738,555	150,635,280
Other Administrative Expenses etc.	21	89,066,559	86,050,364
Expenditure on grants Subsidies etc (Plan grant Surrendered)	22	-	9,342,985
Interest Paid	23	-	-
Depreciation (Corresponding to Schedule 8)		105,820,621	93,473,984
TOTAL (B)		**408,625,735**	**339,502,613**
Balance being excess of Expenditure over Income (B-A)		(32,245,322)	23,096,604
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/ CAPITAL FUND		**(32,245,322)**	**23,096,604**
SIGNIFICANT ACCOUNTING POLICIES	24		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS	25		

In terms of our report of even date annexed

For LAL DAS[illegible]
Chartered Accountants

A.K. SAMANTARAY FCA
PARTNER
M.No.063226

Place : Bhubaneswar
Date : 28-08-2017

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

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 1 - CORPUS/CAPITAL FUND				
Balances as at the beginning of the year		70,68,32,174		68,37,35,571
Add : Contributions towards Corpus/Capital Fund	-		-	
Add/(Deduct) : Balance of Income/(Expenditure) transferred from Income & expenditure Account	(3,22,45,322)	(3,22,45,322)	2,30,96,604	2,30,96,604
Balances as at the year end		**67,45,86,852**		**70,68,32,175**

LAL DASH & CO. BBSR Chartered Accountants

लेखा अधिकारी/ACCOUNTS OFFICER
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 2017

(Amount - Rs.)

	FUND-WISE BREAK UP		TOTALS	
	TPSC	LKP	Current Year	Previous Year
SCHEDULE 3 - EARMARKED/ENDOWMENT FUNDS				
a) Opening balance of the funds	74,864	1,97,833	2,72,697	1,49,700
b) Additions to the Funds:				
i. Donations/grants	35,000	-	35,000	94,000
ii. Income from Investments made on account of funds	2,330	12,316	14,646	63,527
	37,330	12,316	49,646	1,57,527
TOTAL (a+b)	**1,12,194**	**2,10,149**	**3,22,343**	**3,07,227**
c) Utilisation/Expenditure towards objectives of funds				
i. Revenue Expenditure				
- Salaries, Wages and allowances etc.	-	-	-	6,000
- Other Administrative Expenses	1,06,147	-	1,06,147	23,530
- Scholarship	-	5,000	5,000	5,000
Total	1,06,147	5,000	1,11,147	34,530
TOTAL (c)	**1,06,147**	**5,000**	**1,11,147**	**34,530**
NET BALANCE AS AT THE YEAR-END (a+b-c)	**6,047**	**2,05,149**	**2,11,196**	**2,72,697**

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

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 7 - CURRENT LIABILITIES AND PROVISIONS:				
A. CURRENT LIABILITIES				
1. Statutory Liabilities:				
NPS Recovery Payable	50,535		-	
Professional Tax Payable	53,225		-	
TDS Non-Salary Payable	1,77,506		-	
WCT Recovery Payable	3,44,266		-	
		6,25,532		-
2. Other Liabilities:				
Earnest money Deposit	10,82,792		17,01,937	
Caution money from Scholars	8,600		7,800	
GSLI Claim Payable	36,746		-	
Pension Payable	1,31,798		-	
Project Grant Payable	12,46,000		-	
Provision for Expenses	4,01,36,630		1,61,51,958	
Security Deposit - contractors	22,47,208		13,14,077	
		4,48,89,774		1,91,75,772
TOTAL (A)		**4,55,15,306**		**1,91,75,772**
B. PROVISIONS				
1. Gratuity		7,03,06,690		5,65,95,824
2. Superannuation / Pension		-		-
3. Accumulated Leave Encashment		6,39,20,615		4,99,19,045
4. Others (Specify)		-		-
TOTAL (B)		**13,42,27,305**		**10,65,14,869**
TOTAL (A + B)		**17,97,42,611**		**12,56,90,641**

LAL DASH & CO. Chartered Accountants BBSR

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भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2017

(Amount - Rs.)

SCHEDULE 8 - FIXED ASSETS											
	GROSS BLOCK				DEPRECIATION					NET BLOCK	
DESCRIPTION	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	19,75,37,477	68,53,408	-	20,43,90,885	4,00,31,808	1.63	33,31,571	-	4,33,63,379	16,10,27,506	15,75,05,669
3. ROADS	51,41,225	14,06,933	-	65,48,158	19,53,623	19.00	12,44,150	-	31,97,773	33,50,385	31,87,602
4. PLANT MACHINERY & EQUIPMENT	74,69,87,799	1,88,34,117	-	76,58,21,916	27,90,79,712	5.28	4,04,35,397	-	31,95,15,109	44,63,06,807	46,79,08,087
5. COMPUTER/PERIPHERALS	7,07,92,586	6,09,56,624	-	13,17,49,210	6,75,90,322	16.21	2,13,56,547	-	8,89,46,869	4,28,02,341	32,02,264
6. Capital Work in Progress	-	-	-	-	-	-	-	-	-	-	-
TOTAL (A)	**1,02,54,59,087**	**8,80,51,082**	**-**	**1,11,35,10,169**	**38,86,55,465**		**6,63,67,665**	**-**	**45,50,23,130**	**65,84,87,039**	**63,68,03,622**
B. FIXED ASSETS (NON-PLAN)											
1. VEHICLES	26,45,742	-	-	26,45,742	17,55,170	9.50	2,51,345	-	20,06,515	6,39,227	8,90,572
2. FURNITURE, FIXTURES	2,13,32,263	5,72,267	-	2,19,04,530	2,10,39,953	9.50	54,365	-	2,10,94,318	8,10,212	2,92,310
3. OFFICE EQUIPMENT	12,54,87,204	6,49,469	-	12,61,36,673	12,23,01,917	9.50	61,700	-	12,23,63,617	37,73,056	31,85,287
4. ELECTRIC INSTALLATIONS	79,05,702	-	-	79,05,702	49,22,074	6.33	5,00,431	-	54,22,505	24,83,197	29,83,628
5. LIBRARY BOOKS	37,33,33,473	3,28,25,634	-	40,61,59,107	29,02,07,150	9.50	3,85,85,115	-	32,87,92,265	7,73,66,842	8,31,26,323
TOTAL (B)	**53,07,04,384**	**3,40,47,370**	**-**	**56,47,51,754**	**44,02,26,264**		**3,94,52,956**	**-**	**47,96,79,220**	**8,50,72,534**	**9,04,78,120**
TOTAL OF CURRENT YEAR (A+B)	**1,55,61,63,471**	**12,20,98,452**	**-**	**1,67,82,61,923**	**82,88,81,729**		**10,58,20,621**	**-**	**93,47,02,350**	**74,35,59,573**	**72,72,81,742**
PREVIOUS YEAR	1,39,08,95,349	16,55,52,022	2,83,900	1,55,61,63,471	73,56,22,599		9,34,73,984	2,14,854	82,88,81,729	72,72,81,742	65,52,72,750

LAL DASH & CO. Chartered Accountants BSSR

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

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC.				
A. CURRENT ASSETS:				
1. Inventories:				
a) Electrical Fittings Stock	9,43,219		5,25,168	
b) Office Stationery	1,07,514		1,00,736	
c) Computer Stationery	6,92,282		4,60,000	
d) Cleaning Material Stock	56,306		65,996	
e) Diesel Stock	93,306		23,159	
f) Carpentry Material Stock	1,81,279		49,159	
g) PH Material Stock	1,98,291		77,565	
		22,72,197		13,01,783
2. Cash balances in hand (including cheques/ drafts and imprest)		31,622		4,138
3. Bank Balances:				
a) With Scheduled Banks:				
i) In current accounts SBI	2,14,81,712		99,74,635	
ii) SBI LK Panda TD A/c	1,00,000		1,00,000	
		2,15,81,712		1,00,74,635
b) Savings accounts				
i) IOB CS Pur (Non-Plan)	4,54,03,617		2,32,32,003	
ii) IOB CS Pur (Plan)	1,40,98,177		4,43,07,151	
iii) UBI CS Pur (Non-Plan)	1,19,274		24,68,336	
iv) UBI CS Pur (Plan)	47,93,592		84,74,715	
v) SBI LK Panda A/c	1,05,149		97,833	
vi) UBI TPSC A/c	6,047		74,864	
		6,45,25,856		7,86,54,902
TOTAL (A)		**8,84,11,387**		**9,00,35,458**

LAL DASH & CO. BBSR Chartered Accountants

ACCOUNTS OFFICER
REGISTRAR
INSTITUTE OF PHYSICS
BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2017

(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	44,400		53,050	
b) Motor Cycle Advance	27,250		26,250	
c) Motor Car Advance	26,000		38,000	
d) House Buildings Advance	16,000		28,000	
		1,13,650		1,45,300
2. Interest Accrued but not due on Loans				
a) Motor Cycle Advance	-		-	
b) Motor Car Advance	-		-	
c) House Buildings Advance	83,798		1,49,316	
d) Computer Advance	10,919		20,048	
		94,717		1,69,364
3. Loans (Non-Interest bearing):				
a) Staff Advance	16,801		30,300	
b) Medical Advance	1,68,150		71,000	
c) Festival Advance	1,13,400		1,89,900	
d) Cycle Advance	-		1,375	
		2,98,351		2,92,575
4. Advances and other amounts recoverable in cash or in kind or for value to be received:				
a) On Capital Account	5,57,428		30,49,649	
b) Prepayments	92,101		6,75,051	
c) Security deposit With CESCO	26,21,944		26,21,944	
d) Franking machine deposit	24,416		27,555	
e) Security Deposit with BSNL	2,000		2,000	
f) Security Deposit for GAS	20,950		20,950	
g) STDR against L/C	1,83,35,912		76,29,325	
h) SSB Grant Receivable	-		1,80,000	
		2,16,54,751		1,42,06,474
TOTAL (B)		**2,21,61,469**		**1,48,13,713**

B S R — Chartered Accountants

DIRECTOR
INSTITUTE OF PHYSICS
BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF BALANCE SHEET AS AT 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 11 - CURRENT ASSETS, LOANS, ADVANCES ETC. (Contd.)				
C. LOANS, ADVANCES AND OTHER ASSETS				
1. Non-Plan Grant-in-Aid Receivable		-		-
2. Travel Advances (Non-Interest bearing)		4,08,230		6,64,600
3. Rent receivable		-		-
TOTAL (C)		**4,08,230**		**6,64,600**
TOTAL (A + B + C)		**11,09,81,086**		**10,55,13,771**

LAL DASH & CO. BBSR Chartered Accountants

लेखा अधिकारी/ACCOUNTS OFFICER
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

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

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 13 - GRANTS/ SUBSIDIES				
1. DAE - Government of India				
a) Non-Plan (Salary)	173,568,000		137,000,000	
b) Non-Plan (General)	94,500,000		111,400,000	
c) Plan	102,991,000		110,000,000	
		371,059,000		358,400,000
2. Government Of Orissa (Non-Plan Revenue)		-		-
TOTAL		**371,059,000**		**358,400,000**

T.A.L DASH & CO. BBSR Chartered Accountants

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

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 17 - INTEREST EARNED				
1. On Term Deposits:				
a) With Scheduled Banks	-		-	
b) Others (L/C & Security Deposit)	410,162		463,086	
		410,162		463,086
2. On Savings Accounts:				
a) With Scheduled Banks		2,838,731		2,022,641
3. On Loans:				
a) Computer Advance	5,425		33,026	
b) House Building Advance	-		-	
c) Motor Cycle Advance	-		3,019	
d) Motor Car Advance	-		-	
e) Pending Advance	2,253		-	
		7,678		36,045
TOTAL		**3,256,571**		**2,521,772**

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 18 - OTHER INCOME				
1. Miscellaneous Income		803,096		397,807
2. Sale of Tender paper		42,750		142,300
3. House/Guest House Rent		1,212,296		1,128,074
4. Sale of Assets		6,700		9,264
TOTAL		**2,064,842**		**1,677,445**

LAL DASH & CO. Chartered Accountants BBSR

लेखा अधिकारी/ACCOUNTS OFFICER
भौतिकी संस्थान/INSTITUTE OF PHYSICS
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भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 20 - ESTABLISHMENT EXPENSES				
1. Salaries and Wages				
a) Staff Salary	102,778,108		77,005,162	
b) NPS Contribution	2,053,787		1,408,200	
c) Honorarium	1,086,793		1,368,072	
d) Fellowship	12,189,075		20,348,702	
e) Temporary Status Employee Salary	196,360		173,884	
f) Remuneration to Medical Officer	380,000		300,000	
		118,684,123		100,604,020
2. Allowances and Bonus				
a) PRIS	19,242,160		5,440,267	
b) Update Allowance	1,276,298		1,192,324	
c) Overtime Allowance	69,151		92,674	
d) Night Duty Allowance	122,366		137,091	
		20,709,975		6,862,356
3. Staff Welfare Expenses				
a) Reimbursement of Medical Expenses	3,421,182		3,376,912	
b) Canteen Expense	78,374		42,932	
c) Recreation & Welfare Expenses	1,584,743		565,672	
d) Children Education Allowance	942,285		928,606	
e) Medical Aid Centre Expenses	-		700	
		6,026,584		4,914,822
4. Retirement and Terminal Benefits				
a) Leave salary	17,038,727		5,833,841	
b) Pension	32,817,621		18,991,717	
c) Gratuity	17,317,589		12,138,278	
		67,173,937		36,963,836
5. Others				
a) Contigency Grant to Scholars		1,143,936		1,290,246
TOTAL		**213,738,555**		**150,635,280**

LAL DASH & CO. Chartered Accountants BBSR

REGISTRAR
INSTITUTE OF PHYSICS
BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES ETC.				
1.) MAINTENANCE - a) Civil	7,341,076		4,882,169	
b) Vehicle	706,880		662,504	
c) Library	138,837		151,535	
d) Workshop	176,608		46,994	
e) Furniture	205,407		63,059	
f) Electrical	1,355,439		592,796	
g) AC Plant	3,359,673		2,855,223	
h) Computer	4,535,296		3,966,196	
i) Laboratory	2,461,556		2,801,744	
j) Garden	163,982		198,365	
k) Telephone	278,077		827,854	
l) Office Equipment	272,435		249,566	
		20,995,266		17,298,005
2. Electricity and power		22,656,449		29,977,242
3. Water charges		277,789		263,385
4. Conference & Symposia		286,839		185,034
5. Science Outreach Activities		297,139		110,814
6. Postage & Telegram		148,320		142,807
7. Telephone & Telex		452,317		295,396
8. Printing and Stationery		554,614		552,693
9. Travelling Expenses - a) Conference TA	565,242		252,502	
b) Foreign Travel	603,560		41,933	
c) Visiting scientist TA	366,263		457,961	
d) Domestic Travel	1,145,591		1,239,425	
e) Leave Travel concession	605,668		835,909	
f) Hire Charge	6,638		13,555	
		3,292,962		2,841,285
SUB-TOTAL (A)		**48,961,695**		**51,666,661**

P.K. DASH & CO. Chartered Accountants

वरिष्ठ अधिकारी/ACCOUNTS OFFICER
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

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

INSTITUTE OF PHYSICS, BHUBANESWAR

SCHEDULES FORMING PART OF STATEMENT OF INCOME & EXPENDITURE FOR THE YEAR ENDED 31ST MARCH 2017

(Amount - Rs.)

	Current Year		Previous Year	
SCHEDULE 21 - OTHER ADMINISTRATIVE EXPENSES Contd....				
10. Auditors Remuneration		59,000		57,750
11. Entertainment Expenses		425,684		415,855
12. Security Charges		8,574,915		6,608,391
13. Professional Charges		219,690		401,360
14. Project Revenue Expenses				
a) ALICE Utilisation and CBM Participation	2,676,431		2,622,324	
b) Development of Computing and Network Facilities	6,171,803		1,599,458	
c) Development of Research in HEP	3,193,975		975,853	
d) Development of Research in NP	1,836,010		1,309,298	
e) Strengthening Low Energy Accelerator	1,414,450		304,537	
f) Study of Growth and Characterisation	4,249,544		3,046,016	
g) Theoretical CM and QI	3,184,368		1,799,574	
h) Infrastructure and Housing	7,444,049		11,374,109	
		30,170,630		23,031,169
15. Advertisement and Publicity		423,985		950,662
16. Year-Long Academic activities		-		2,635,618
17. Others				
a) Miscellaneous Expenses	230,960		250,188	
b) Loss on Sale of Asset	-		32,710	
		230,960		282,898
SUB-TOTAL (B)		**40,104,864**		**34,383,703**
GRAND TOTAL (A + B)		**89,066,559**		**86,050,364**

LAL DASH & CO. Chartered Accountants BBSR

REGISTRAR
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

INSTITUTE OF PHYSICS, BHUBANESWAR
STATEMENT OF RECEIPTS & PAYMENTS FOR THE FINANCIAL YEAR 2016-17

(Figure in Rs.)

	RECEIPTS	SCH	Current Year	Previous Year		PAYMENTS	SCH	Current Year	Previous Year
I.	**Opening Balances**				I.	**Expenses**			
	a) Cash in hand		4,138	33,592		a) Establishment Expenses (Corresponding to Sch 20)	D	163,141,059	138,890,783
	b) Bank balances					b) Administrative Expenses (Corresponding to Sch 21)	E	58,098,473	65,166,719
	i) In current accounts SBI		9,974,635	12,272,793	II.	**Payments made against funds for various projects**			
	ii) In deposit accounts					TPSc		106,147	29,530
	LK Panda (SBI Term Deposit)		100,000	100,000		LK panda Scholarship		5,000	5,000
	iii) In Savings accounts				III.	**Investments and deposits made**			
	Indian Overseas Bank (NP)		23,232,003	17,425,370		a) Out of Earmarked/Endowment funds		-	-
	Indian Overseas Bank (Plan)		44,307,151	33,153,164		b) Out of Own Funds (Investments-Others)		-	-
	Union Bank (NP)		2,468,336	81,339	IV.	**Expenditure on Fixed Assets & Capital W.I.P**			
	Union Bank (Plan)		8,474,715	7,507,354		a) Purchase of Fixed Assets	F	124,750,262	116,721,534
	SBI (LK Panda)		97,833	42,142		b) Expenditure on Work-in-Progress		-	-
	Union Bank (TPSC)		74,864	7,558	V.	**Refund of surplus money/Loans**			
II.	**Grants Received**					a) To the Government of India		-	-
	a) From Govt. of India - Plan		102,991,000	110,000,000		b) To the State Government		-	-
	Non-Plan		268,068,000	248,400,000		c) To other providers of funds		-	-
	b) From State Government		-	-	VI.	**Finance Charges (Interest)**		-	-
	c) TPSC		35,000	94,000	VII.	**Other Payments**			
III.	**Income on Investments from**					Project Revenue Expenses	G	35,365,487	23,449,994
	a) Earmarked/Endow. Funds	A	14,646	63,527		Staff Loan	H	345,150	1,117,435
	b) Own Funds (Oth.Investment)		-	-	VIII.	**Closing Balance**			
IV.	**Interest Received**					a) Cash in hand		31,622	4,138
	a) On Bank deposits		2,838,731	2,022,641		b) Bank balances			
	b) Loans, Advances etc.	B	492,487	569,105		i) In current accounts SBI		21,481,712	9,974,635
V.	**Other Income**					ii) In deposit accounts			
	Misc Receipts		731,532	326,000		LK Panda (SBI Term Deposit)		100,000	100,000
	Sale of Tender paper		42,750	142,300		iii) Savings accounts			
	House/Guest House Rent		1,212,296	1,215,329		Indian Overseas Bank (NP)		45,403,617	23,232,003
	Sale of Asset		6,700	-		Indian Overseas Bank (Plan)		14,098,177	44,307,151
VI.	**Amount Borrowed**		-	-		Union Bank (NP)		119,274	2,468,336
VII.	**Any Other Receipts**					Union Bank (Plan)		4,793,592	8,474,715
	Earnest Money Deposit		(594,645)	523,992		SBI (LK Panda)		105,149	97,833
	Security Deposit		978,395	(279,336)		Union Bank (TPSC)		6,047	74,864
	Caution Money		2,600	1,000					
	Recoveries / Current Dues	C	2,397,601	412,800					
	TOTAL		**467,950,768**	**434,114,670**		**TOTAL**		**467,950,768**	**434,114,670**

For LAL DASS
Chartered Accountants

A.K. SAMANTARAY FCA,
PARTNER
M.No 063226

ACCOUNTS OFFICER
INSTITUTE OF PHYSICS
BHUBANESWAR

INSTITUTE OF PHYSICS
BHUBANESWAR

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31.03.2017

SCHEDULE 24 - SIGNIFICANT ACCOUNTING POLICIES

1. **ACCOUNTING CONVENTION**

   The financial statements are prepared and presented on the basis of historical cost convention and on the accrual method of accounting.

2. **INVENTORY VALUATION**

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

3. **INVESTMENT**

   The Institute has no long-term Investment of any nature. However, there are short-term investment in shape of STDR with bank against Letter of Credit.

4. **FIXED ASSETS**

   Fixed Assets are stated at cost of acquisition inclusive of Carriage Inward, duties & taxes and other incidental direct expenses incurred in relation to such particular fixed assets.

5. **DEPRECIATION**

   5.1. Depreciation is provided on straight-line method at the rates specified in the Company Act, 1956, the amendment of 2013 has not been taken into account. Depreciation has been charged on those assets whose WDV are 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.

L.K. DASH & CO. Chartered Accountants BBSR

DIRECTOR
INSTITUTE OF PHYSICS
BHUBANESWAR

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.

6.3. The balance available under Plan grant is shown as Unutilised grant carried forward.

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 31.03.2017. 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 31.03.2017 has been provided in accounts on actuarial valuation.

9.2. Provision for liability towards accumulated leave encashment benefit to the employees as on 31.03.2017 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 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.

T.K. LAHA & CO. Chartered Accountants BBSR

ACCOUNTS OFFICER INSTITUTE OF PHYSICS BHUBANESWAR

REGISTRAR INSTITUTE OF PHYSICS BHUBANESWAR

INSTITUTE OF PHYSICS
BHUBANESWAR

SCHEDULES FORMING PART OF THE ACCOUNTS FOR THE PERIOD ENDED 31.03.2017

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 31.03.2017 against 100% margin money	NIL
1.5.	Disputed demand in respect of	
	Income Tax (TDS) as on 31.03.2017	NIL
	Sales Tax (IDS)	NIL
	Municipal Taxes	NIL
1.6.	In respect of claims from parties for non-execution of orders	NIL

2. NOTES ON ACCOUNTS

2.1. CURRENT ASSETS. LOANS AND ADVANCES

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

2.2. CURRENT LIABILITIES & PROVISIONS

All known liabilities except Pension to retired employees have been provided in the accounts of the Institute.

LAL DASH & CO. Chartered Accountants BBSR

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/conferences have not been included in the accounts, as their accounts are kept separate.

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. 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.1,83,35,912/- includes the following:

Date of Payment	Head of A/c	Party Name	Item Name	Amount
30/09/2014	Strengthening Low Energy	Prevac, Poland	Ion Cleaner	8,69,502
09/11/2015	Theoretical CMQI	Mels Impex America	Laser Trapping System	1,47,219
18/03/2016	Study of Growth & characterisation	Oxford Instrument	Energy dispersive system	7,74,540
07/12/2016	Computing & Networking	Micropoint Computer	HPC System	63,39,888
07/12/2016	Study of Growth & characterisation	Kimmon Koha Japan	He-Cd Laser	7,97,094
19/01/2017	Strengthening Low Energy	Danfysik, Denmark	Injection Magnetic Coil	30,25,204
31/03/2017	Strengthening Low Energy	NEC USA	Accelerator Spare	38,58,649
31/03/2017	Study of Growth & characterisation	Horiba France	Raman Spectrometer	22,47,709
31/03/2017	Study of Growth & characterisation	Bruker Singapore	Nanoscope V	2,76,107

2.9. Miscellaneous Income includes Unclaimed Liability of Rs.71,564/- towards Caution Money from Scholars (Rs.1,800/-), Security Deposit from Contractors (Rs.45,264/-) & Earnest Money Deposit (Rs.24,500/-).

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 31.03.2017 and Income & Expenditure Account for the year ended on that date.

BBSR

ACCOUNTS OFFICER
INSTITUTE OF PHYSICS
BHUBANESWAR

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

2.12. FOREIGN CURRENCY TRANSACTIONS

Value of Imports calculated on C.I.F/Ex-works & FOB basis	Current Year (Rs.)
a) Purchase of Lab. Equipments	6,49,23,308
b) Stores, Spares and Consumables	1,07,84,183
Expenditure in foreign currency	
a) Travel	1,31,158
b) Other expenditure	Nil
Earnings	
Value of Exports on FOB basis	Nil
Remuneration to Auditors	
As Auditors	Nil

LAL UDASH & CO. Chartered Accountants BBSR

लेखा अधिकारी/ACCOUNTS OFFICER
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

रजिस्ट्रार/REGISTRAR
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भुवनेश्वर/BHUBANESWAR

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

ACTION TAKEN REPORT ON THE COMMENTS OF STATUTORY AUDITOR ON THE ANNUAL ACCOUNTS OF INSTITUTE OF PHYSICS, BHUBANESWAR FOR THE FINANCIAL YEAR 2016-17

Sl. No.	AUDITOR'S OBSERVATION	INSTITUTE'S REPLY
Qualified opinion		
1	IAS 10 regarding to fixed assets and AS 6 for depreciation have not been followed. There was no fixed assets register to verify the individual assets 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 whole year. E-journals are paid on calendar yearly basis but the whole years e-journals have been capitalized thus contravening the provisions of AS10 and AS-6.The depreciation on assets purchased during the year was also charges for full year instead of proportionate basis from date put to use.	The Institute did not have the asset register for long. Steps were taken to compile an Asset Register from the available records through a Chartered Accountants firm selected on open tender basis and the firm has compiled it up to the financial year ending 31.03.211. The Institute has procured an "Asset Management Software" from M/s Wings Infonet Pvt. Ltd. Hyderabad and has out sourced the data entry work to the same farm to update the Asset Register. However, stock taking of Fixed Assets of the Institute as on 31.03.2017 has been done and the soft copy of the report is available in the Intranet of Institute Website as well as in physical form in the office.
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.
3	TDS not deducted under section 194J in case of engagement of persons as consultants and the expenses of salary paid to them are directly booked to maintenance expenses. The same are treated as salary by the institute in computation of Income tax for TDS. Expenses booked under computer maintenance and civil maintenance.	The Institute engages persons on contractual basis and the Income Tax due there from are deducted at source u/s 192 and deposited with tax authority. Income Tax u/s 194J are deducted from the professional charges being paid to the consultant engaged by the Institute.

लेखा अधिकारी/ACCOUNTS OFFICER
भौतिकी संस्थान/INSTITUTE OF PHYSICS
भुवनेश्वर/BHUBANESWAR

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

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

Matter of emphasis		
4	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 were available in the file. Lease record in respect of 6.130 acres was available. The land records of the Institute for 47.32 Acre have been updated in the name of IOP. No land revenue is pending for payment to State Government.	Institute has initiated action to regularize the land record of the Institute. A sum of Rs.1,26,969/- has been deposited on 08.07.2017 with Govt. of Odisha towards the lease rent upto 31.03.2017 in respect of land of 6.130 Acres allotted to the Institute. The land records of the Institute for 47.32 Acre have been updated in the name of IOP. No land revenue is pending for payment to State Government. Action is also being taken to transfer the title of the Land.
5	Balances of advances and liabilities recognized from third Parties are subject to confirmation.	Noted
Audit Observation on Accounts		
6	**Maintenance of books of accounts:** i) The following manual books of accounts are maintained in the year 2016-17: a) Cash cum bank Book b) Cheque issue register c) Staff advance register d) Security deposit register e) TDS register ii) The institute uses a wings accounting package also which is updated every 15 days. The journilasation of transactions were started since April 2016 in the wings package, however the manual cashbook is still maintained on old format.	i) No comment. ii) No comment.
7	**Cash and Bank:** a) Institute didn't have any guidelines for holding minimum cash balance. In many instances the institute has had maintained cash balance above Rs. 10000.00. Few cases are cited at annexure-1. b) In some cases the institute has paid cash above Rs. 20000 to visiting scientists/Employees. Instances given at Annexure-2.	a) The Institute usually maintains minimum cash balance in hand. However during the period of Audit the Institute had to keep some cash balance for payment to visiting scientist against their TA/DA bill. Now the Institute invariably pay the bill by NEFT/RTGS. b) The Institute never make any payment of more than

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		Rs.20,000/- in shape of cash to Suppliers/Contractors. Payment in shape of cash of more than Rs.20,000/- is required to be made to employees to incur expenses for office purposes including academic programme, functions and ceremony.
	c) The Institute had operated 5 Nos. of Bank accounts. All banks have been reconciled and the bank reconciliation statements are given at Annexure-3.	
	i) However from the bank reconciliations it was observed that in case of IOB Non Plan account RS. 20267.00 was debited on 05.10.2016 in the account but the same not accounted for in the cash book yet. The same amount was debited to the Plan account of IOB in cash. The difference was yet to be effected although its 6 months old. The same appears in the banks reconciliation statement of IOP plan account as well as "cheques issued but not presented for payment."	c) (i) Necessary rectification entry is being given in the Accounts for the year 2017-18.
	ii) Balance confirmation certificates from banks were not available for verification. Bank statements were relied upon for balances.	(ii) The balance confirmation certificate from the banks have been obtained.
8	**Non Receipt of journals:** The institute subscribes for journals for its library. Journals paid for but not received as on 31.03.2017 was Rs.45,640.00. The same if not received may be recovered from the suppliers.	Out of the Non Receipted journals of Rs.45,640/- as reported by Audit, Journals worth Rs.26,231/- has been received by the Institute as on 15.08.2017. Other Publishers are being pursued to supply the remaining journals.
9	**Others:**	
	a) Expiry of rent agreement with Bank: There is an Indian overseas bank operating in the campus on rent for 200 sqr. Mtr. of building. The agreement has expired since 30.11.2012. Rate charged still the same at Rs 12500 per month.	a) A new lease agreement has been entered into with the Bank fixing the Rent at Rs.25,000/- per month. The Bank has also paid a sum of Rs.6,87,500/- on 01.08.2017 towards the arrear rent w.e.f. 01.12.2012 up to 31.07.2017.
	b) Electricity Charges: It was observed that electricity charges paid by the institute during the previous years include a portion of NISER	b) The matter has been pursued with NISER and settled on mutual agreement basis.

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operating from IOP campus. The proportionate electricity charges may be recovered from NISER. It was stated in the reply of the management in earlier years that the amount would be recovered from the assets to be left over by NISER after shifting, however no such recovery made although NISER has already left the IOP Campus.

c) Advances to staff unadjusted for more than 3 months were found in few cases. The same should be adjusted/recovered at an earliest. Details as under:

Sl No	Date	Name	Purpose
1.	28.10.2016	Purna Moharana	Medical Advance
2.	23.11.2016	Rajan Biswal	Medical Advance
3.	12-01-2009	Hari Naik	Medical Advance
4.	09.09.2016	Goutam Tripathy	CMQI
5.	09/05/2016	Tabobrata Som	Purchase Adv.

d) Loans outstanding for more than two years: The following staff loans are outstanding for more than two years.

Sl No	Date	Name	Purpose
1.	2007-08	J.K.Mishra	Computer Loan
2.	2004-05	A.M.Srivastava	Motor Car Loan
3.	2005-06	Bhaskar Mallik	Housing Loan

e) There was sale of fixed Assets to the tune of Rs. 6700.00. However the same was shown under Misc. Income. The assets sold have not been deducted from the value of assets and accumulated depreciation.

c) All outstanding advances as indicated have been adjusted/recovered.

d) The long term advances were extended to the employees of the Institute and are being recovered from their Salary every month as per rule.

e) Rs.6700.00 was received towards the residual value for buy back of one refrigerator and one TV and washing machine which were not working. Since the original purchase value of these equipments could not be ascertained to deduct from the value of assets and accumulated depreciation, the same has been shown under Misc. Income.

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भौतिकी संस्थान/INSTITUTE OF PHYSICS


LIBRARY & COMPUTER CENTRE

Institute of Physics

P.O. : Sainik School, Sachivalaya Marg, Bhubaneswar-751005, Odisha, India
Phone No. : +91-674-2306400 / 444 / 555 , Fax : +91-674-2300142
URL : http : // www.iopb.res.in