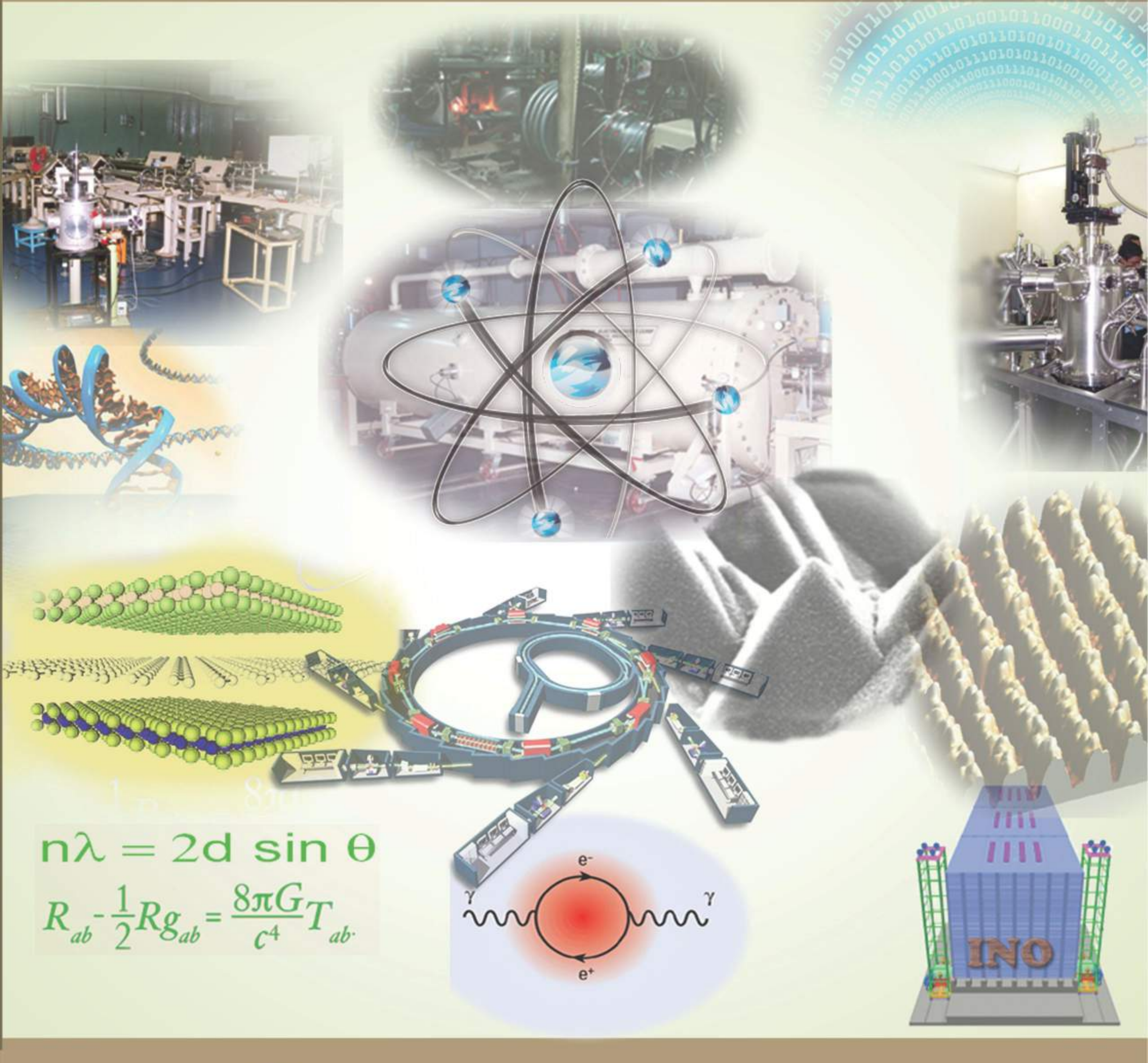
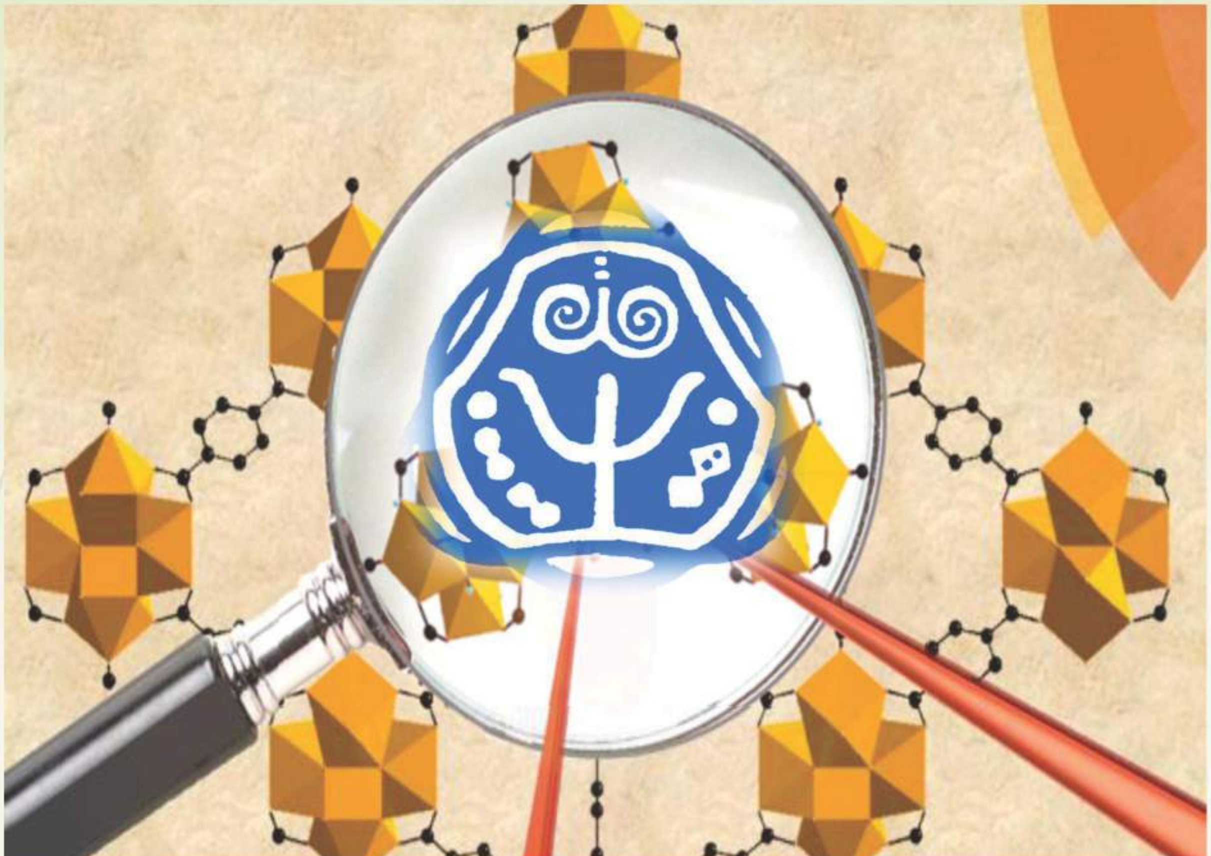
ANNUAL REPORT

2014-15



INSTITUTE OF PHYSICS

BHUBANESWAR




Institute Of Physics

Annual Report

2014-2015

INSTITUTE OF PHYSICS

BHUBANESWAR

INSTITUTE OF PHYSICS

Address
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
Dr. Sanjib Kumar Agarwalla

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Compiled by
Shri Rajesh Mohapatra

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Contents

About the Institute

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

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

The Institute offers Ph.D. programme to the scholars who successfully complete the one year pre-doctoral course at the Institute. The selection for the pre-doctoral programme is through the Joint Entrance Screening Test (JEST). Candidates qualifying the CSIR-UGC NET examination and those having high GATE scores are also eligible for an entry to the pre-doctoral program.

The Institute campus has housing facilities for the employees and hostels for the scholars and post-doctoral fellows. Compact efficiency apartments are available for post-doctoral fellows and visitors. Both indoor and outdoor games and sports facilities are also available in the campus. The Institute has a mini-gym in the New Hostel. The Institute also has a guest house, auditorium, and dispensary in the campus.

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

The Governing Council

Chairman

Prof. S. K. Joshi

Distinguished Emeritus Scientist CSIR
and
Honorary Vikram Sarabhai Professor (JNCASR)
Room. No. 250, National Physical Laboratory,
Dr. K. S. Krishnan Marg, New Delhi - 110 012.

Members

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P.O. Sainik School,
Bhubaneswar-751005.

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Chhatnag Road, Jhunsi,
Allahabad-211019.

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Bhabha Atomic Research Centre,
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Shri K.A.P. Sinha, IAS, (up to 15.09.2014).
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Department of Atomic Energy (B.S),
Room No.145- A, South Block,
Central Secretariat, New Delhi-110011

Smt. Nisha Singh, IAS, (from 23.09.2014)
Joint Secretary,
Department of Atomic Energy (B.S),
Room No.145- A, South Block,
Central Secretariat, New Delhi-110011

Shri R.A.Rajeev, IAS, (from 01.10.2014)
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Department of Atomic Energy,
Anushakti Bhavan, C.S.M. Marg,
Mumbai-400001

Dr. C. S. Kumar, IAS,
Commissioner-cum-Secretary,
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Employment and Technical Education &
Training Department,
Bhubaneswar-751001.

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School of Basic Sciences,
Indian Institute of Technology,
Bhubaneswar-751013.

Prof. Simanchal Panigrahi,
Department of Physics,
National Institute of Technology,
Rourkela-769008, Odisha.

Prof. Sudhakar Panda,
Director, Institute of Physics,
Bhubaneswar-751005.

Shri K. Padmanabhan, (up to 24.04.2014).
Officer on Special Duty,
Institute of Physics,
Bhubaneswar-751005

Dr. B.C.Parija, (from 25.04.2014).
Officiating Registrar, Institute of Physics,
Bhubaneswar-751005

From Director's Desk . . .

The research activities carried out during the preceding year at Institute of Physics, Bhubaneswar has been captured in its Annual Report 2014-2015.

During this period, active measures have been taken for all round developments of the academic activities as well as administration of the Institute. The Peer Review Committee consisting of eminent scientists of the country visited IOP and gave their assessment as excellent. Attempts are underway to implement their suggestions. During the said period, IOP faculty have carried out excellent research works by publishing 113 papers in the International Peer Reviewed Journals. Faculty members and scholars have received prestigious national and international awards/honours like Fellow of INSA, Simons Associateship of The Abdus Salam International Centre for Theoretical Physics (ICTP), National Academy of Sciences (NASI) - Young Scientist Platinum Jubilee Award, Indian National Science Academy (INSA) Medal for Young Scientists, Best poster Award in International Symposium of Multi-particle Dynamics, Bologna, Italy.

Thoughtful and planned steps have been taken to hire young dynamic faculties for accelerated growth of the institute. In fact some new members have already joined and some more will do so by the end of the year. We plan to fill up all the vacant faculty positions within next two years.

New experimental facilities have been added to the existing ones. For example, Advanced Materials Processing Laboratory was inaugurated by Dr. Ratan Kumar Sinha, Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy, Government of India on 27th June, 2014. This facility has been a great help for experimental scientists of the Institute to achieve their goals.

We participated in the diamond jubilee celebration of the Department of Atomic Energy by successfully organizing the Science Outreach Programme on 1st February, 2015 where more than 300 School Students participated. The goal was the popularization of science among the school children as well as to make them familiar with various activities of DAE. On this occasion, the scientific talk delivered by Mr. S.K. Malhotra, Head, Public Awarness Division, Department of Atomic Energy, Government of India was appreciated not only by the gathering but also by all TV and print media. DAE has also expressed its appreciation about the way this programme was successfully organized.

IOP is celebrating its 40th Year of Academic Activities by ongoing various academic programmes like colloquium series, conferences, workshops through out the year. IOP is playing an important role alongwith other academic institutes and universities in Bhubaneswar like NISER, IIT Bhubaneswar, Utkal University to make Bhubaneswar a major basic science hub of the eastern part of our country.

We have concrete plans to enhance the academic activities of the Institute using the infrastructure which will be available once NISER moves to its permanent campus.

I am optimistic that the research work being carried out at IOP will stand in front line amongst other research institutions of DAE.

(Prof. Sudhakar Panda)

1 FACILITIES

1.1 EXPERIMENTAL FACILITIES

New Facility
Advanced Materials Processing Laboratory

Newly established Advanced Materials Processing Laboratory in the Institute Campus was inaugurated by Dr. R.K. Sinha, Chairman, Atomic Energy Commission and Secretary, Department of Atomic Energy on 27th June, 2014.

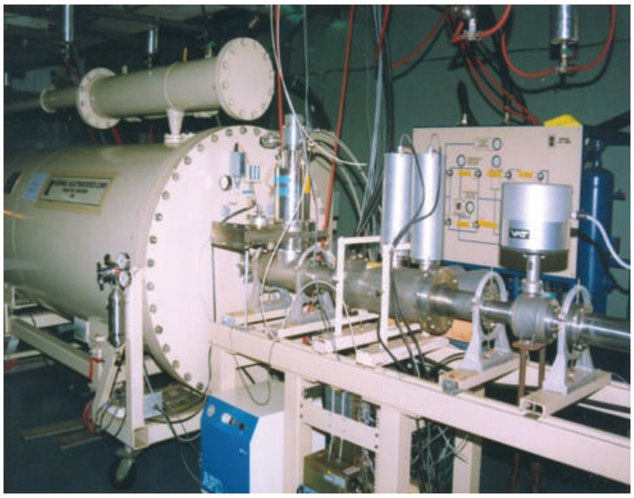
The laboratory houses equipment for conducting research in several frontier areas on thin films and nanomaterials. Using the facilities existing here, samples can be prepared under sensitive and controlled conditions and can be investigated for their morphological, magnetic, optical, vibrational properties.

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.

CMPF System

ION BEAM FACILITIES
Ion Beam Laboratory



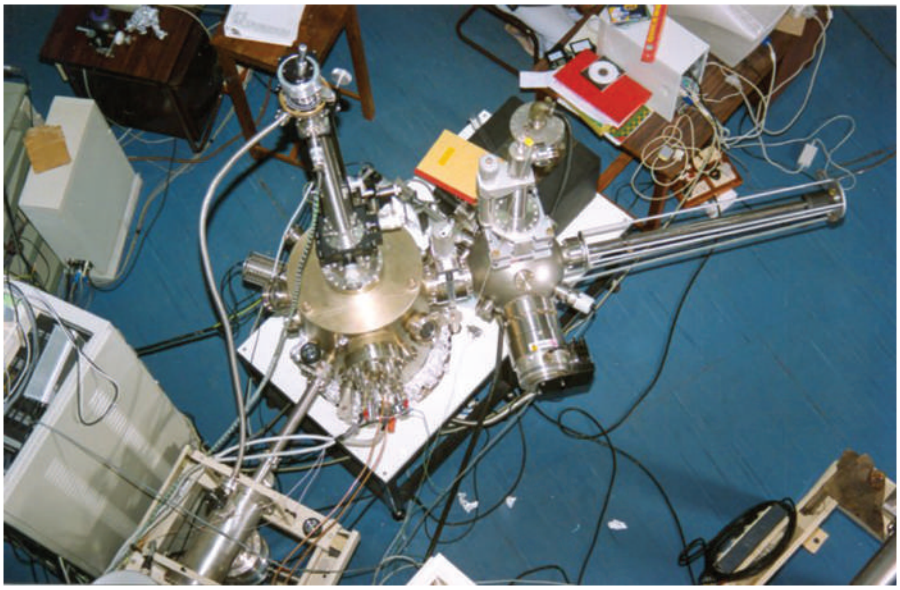
The Ion Beam Laboratory houses the NEC 3 MV tandem Pelletron Accelerator which is one of the major facilities used by researchers from all over the country. The accelerator provides ion beams of energies typically 1-15 MeV starting from protons and alphas to heavy ions. Commonly used ion beams are that 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 a 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



modules and the data acquisition system is interfaced with a computer.

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

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

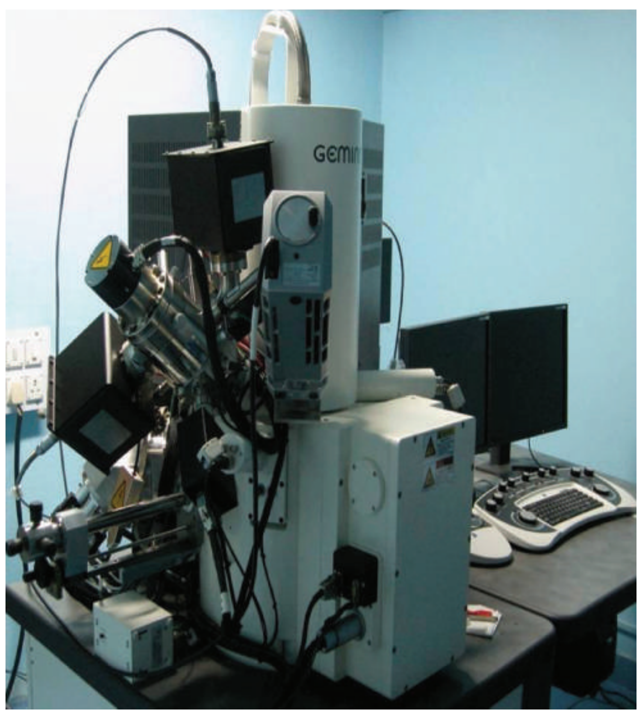
HRTEM Laboratory :

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 LaB_6 filament assures a high quality lattice imaging with a point-point to 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 LN_2 – minimum temperature achievable is $\approx$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.

A combination of Field Emission Gun based Scanning Electron Microscope and Focused Ion Beam imaging (FEGSE-FIB) is used to image nanoscale features and modify these structures while observing the structural evaluation with SEM. The above facility is model Neon 40 Cross Beam, from Ziess GmbH, Germany.

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-organizedpatterned 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

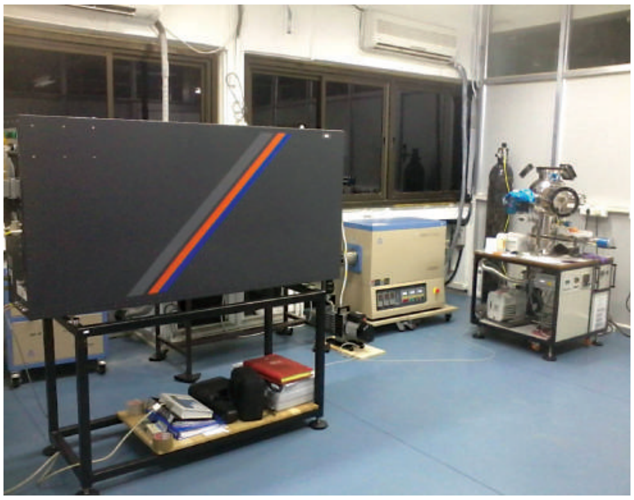
kinetic energy distribution of electrons photo-ejected by x-rays from a sample provides a map of the discrete atomic levels, specially the core levels of the constituent atoms with in the material. Another very important aspect of XPS is the ability to distinguish different chemical environments of atoms; 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

This is a newly installed facility. 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.

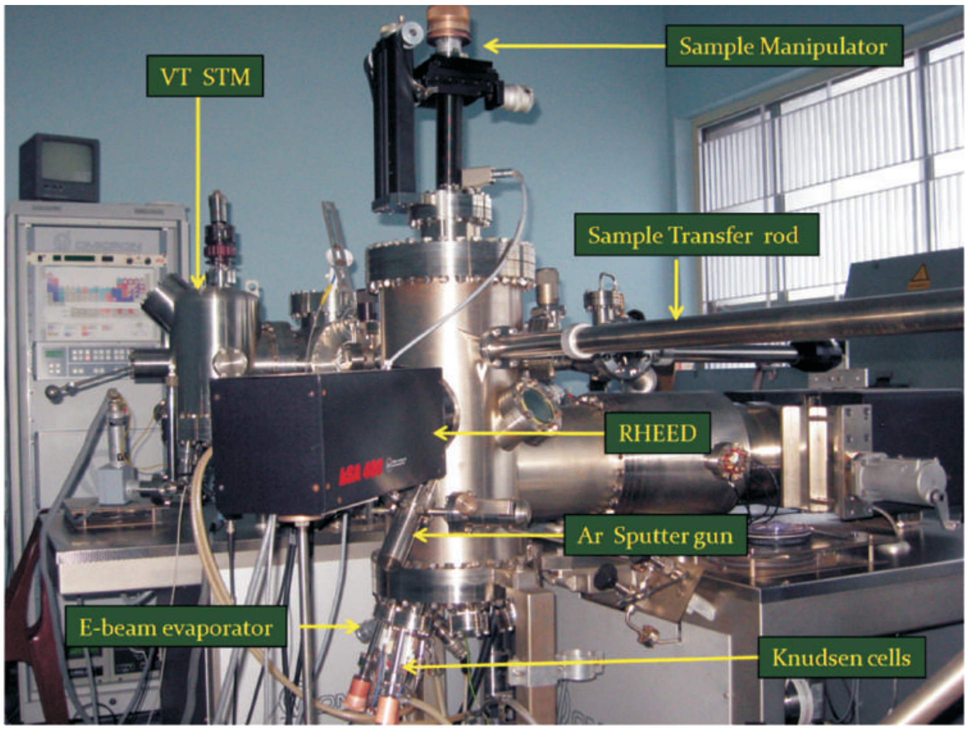
DC/RF Magnetron Sputtering

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 600^0 C) for film growth at elevated temperatures. We have an additional and dedicated gun for deposition of three-dimensional nanostructures by using glancing angle deposition. Further, we have a load lock and a plasma chamber for making nitride and/or oxide layers in vacuum. We can grow thin films of semiconductors, metals, and compounds having a wide variety of morphology and grain size. In turn, their physical properties can also be tuned. Research using this facility is aimed at developing advanced materials having novel structures and tunable properties. The system is mainly aimed to grow materials on templated

substrates and compare change in their physical properties driven by anisotropy in substrate morphology. We have taken up a program to grow thin films and naostructures having applications in solar cell, spintronics, and nanophotonics.

MBE – VTSTM

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



STRUCTURAL PROPERTY MEASUREMENT FACILITIES

High Resolution X-ray Diffractometer (HRXRD)

High Resolution X-Ray defractometer (D8 Discover) can operate in grazing as well as powder XRD mode. The HRXRD system has flexibility with possible combinations of the x-ray source, optics, sample stages, and the detectors. The system consists of goniometer, short tracks, vertical, 150 mm, 3 kW X-Ray generator, grazing incidence attachment for thin film analysis with parallel beam mirror for better data quality, push plug Göbel Mirror, Cu radiation source with a set of slits for Goebel Mirror, flat LiF monochromator and set of plug-in slits, Ni K_β 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

UV-Vis-NIR Spectrophotometer

Shimadzu-make UV-3101PC spectrophotometer with PbS detector (for longer wavelengths) is available at Cluster & Nanostructure Lab. The spectrophotometer uses two sets of gratings to cover a wide range of wavelengths (200-3200 nm). Both solid and liquid samples can be used for experiments. Optical properties viz. band gap estimation, quality of the crystal etc. can be studied. The instrument can operate in absorbance, transmission and diffused reflectance mode.

Fluorescence Spectrometer

Oriel-make fluorescence assembly comprising of double monochromators, excitation source (Hg-Xe lamp) and PMT (250-850 nm) detector is available at Cluster & Nanostructure Laboratory. Temperature (down to liquid-nitrogen temperature) effect on luminescence can be studied for semiconductors, oxides and organic compounds. This instrument can identify trap states, band edges of semiconductors and also new organic compounds based on luminescence properties of materials.

Spectral Response System

This system (procured from Sciencetech, Canada) includes a 150 W Xenon light source, a monochromator to tune the light source, and the necessary probes to attach to the sample. A source meter used as an active load permits operating the test cell at various load conditions, including short-circuit, compensating for a series resistor required to sense the current produced by the modulated monochromatic light. This sensed current plus a reference signal at the frequency of the light modulation are both fed into the precision lock-in amplifier to allow measurement of thephotocurrent generated by the modulated monochromatic light.

By a combination of resistivity setup and spectral response system, one can measure these parameters of thin films:

(1) Photocurrent versus voltage characteristic with fixed or variable wavelength.

(2) Current versus time (response of photocurrent) or in simple word one can measure switching effect.

(3) Photoconductivity of a thin film.

(4) Band gap

(5) Defect density in the band gap

X-Ray Fluorescence (SRF) Spectrometer

A small portable XRF facility based on fixed tube source (0.1 kW) and using a energy dispersive system to study the toxic elements (high Z) in fly ash products and elemental analysis in some wood samples.

ELECTRICAL PROPERTY MEASUREMENT FACILITIES

Cyclic Voltametry

A Potentiostat- Galvanostat, from Autolab, has been procured which can be utilized to investigate the electroanalystical properties like electrocatalysis, electrodepostion for semiconductors, dielectric materials, polymers, membranes etc. Cyclic Voltametry is an effective technique to study redox systems. It enables the electrode potential to be rapidly scanned. In cyclic Voltametry experiment the working electrode potential is ramped linearly versus time. The voltagrams are utilized to study the electrochemical properties of an analyte solution. Application areas include conductive coatings, polymers, semiconductors, batteries, fuel cell, super capacitors etc.

LCR Meter

The interfacial capacitance-voltage (C-V) measurement can be carried out using the LCR meter, HP make LCR meter (model: 4284A) in SUNAG lab. The LCR meter has the capability to measure the conductance (L), capacitance (C), and resistance (R) of the semiconductor device over a wide range of frequencies (20Hz to 1MHz) and test signal levels (5 mV to $2V_{rms}$, 50 μA to 20 mA_{rms}).

We have other facilities like

- Chemical Labs (with ductless fumehood (Esco-make), centrifuge, LB film deposition set-up (Nima-make), Spin coater, MilliPore Water purifiers)
- Furnaces : Rapid Thermal Annealing Unit, Low Vacuum Furnace.
- CVD set-up (indigenously build)
- HV thin film deposition unit (Hind Hivac-make)
- Ion Miling Station
- Plasma Cleaner for TEM specimen preparation

1.2 COMPUTER FACILITY

The computer facility in the Institute of Physics can be broadly divided into that 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 Institute, the computer facility of Institute is being used by researchers in several universities and colleges in Orissa for academic work.

1.3 LIBRARY

The Library facility is available to the members of the Institute, NISER as well as members from other academic institutions. The Library holdings include 15,661 books and 23,643 bound Journals, taking the total collection to 39,304. Throughout the year the Library added 377 books to its collection. The

Library subscribed to 135 Journals. 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 Volume.1 with perpetual access right to back files and full archives containing all articles published since 2011. Besides this, Library is a part of the Dept. of Atomic Energy Consortium with Elsevier Science from 2014 - 2016 getting access to around 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).

LIBRARY BUILDING

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.

The Library cataloging is fully automated with Libsys4 (Rel.6.2) 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.

Facilities like photocopying has also been automated with user codes. During the year under report, a total no of 20,000 pages were photocopied for research purposes and official work. The Library also takes care of the Auditorium and Lecture hall facilities of the 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.

IOP Auditorium

2

ACADEMIC PROGRAM

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 the Institute has a regular Pre-doctoral (post M.Sc.) course.

The pre-doctoral program of the Institute of Physics is a very important academic program because it is designed to train the M.Sc. students for carrying out research activities. The 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 conducting the written test for the Ph.D. program in physics for students across the country. The final selection of a student is made after an interview conducted at the Institute. The Pre-doctoral course began in August, 2013 and ended in June, 2014 leading to a Diploma in Advanced Physics awarded by the Institute. The Utkal, Berhampur and Sambalpur Universities have recognized the diploma as equivalent to their M.Phil degrees. On completion of the Pre-doctoral program, the students are eligible to join research under supervision of faculty members of the Institute, leading to the Ph.D. degree awarded by Utkal University or Homi Bhabha National Institute (HBNI).

To recognize the talent, the Institute has instituted the 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 218 students were called for interview for admission to the predoctoral course in July, 2014. This includes JEST qualifiers, UGC-CSIR qualifiers and valid GATE score holders. Out of those who were admitted, the following students have successfully completed the pre-doctoral course in July, 2015:

1. Mr. Amit Kumar
2. Mr. Biswajit Das
3. Mr. Debashis Mallick
4. Mr. Ganesh Chandra Paul
5. Mr. Partha Paul
6. Mr. Pratik Roy
7. Mr. Sujay Shil
8. Mr. Vijigiri Vikas

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

Trimester – I (August - November)

Quantum Mechanics	: Dr. P. Agrawal
Mathematical Methods	: Dr. A. Virmani
Classical Electrodynamics	: Dr. A.M. Srivastava
Theory of Experiments	: Dr. P. V. Satyam

Trimester – II (December - March)

Statistical Mechanics	: Dr. G. Tripathy
Adv. Quantum Mech.	: Dr. S. K. Patra
Field Theory	: Dr. S. Mukherji
Numerical Methods	: Dr. S. Varma

Trimester – III (April - July)

Cond. Matter. Physics	: Dr. A.M. Jayannavar & Dr. B.R. Sekhar
Particle Physics	: Dr. S. K. Agarwalla
Nuclear Physics	: Dr. P.K. Sahu

As a part of the course work, the pre-doctoral students also worked on projects in the last trimester under supervision of faculty. Titles of the projects undertaken by predoctoral student during 2014-2015 are as given below.

Name of Supervisor	Name of Student	Title of Project
Prof. G. Tripathy	**Amit Kumar**	Non Equilibrium Phase transitions
Prof. P. Agrawal	**Biswajit Das**	Renormalization in QED
Prof. S. K. Agarwalla	**Debashis Mallick**	Neutrino Oscillation and CP violation
Prof. A. Saha	**Ganesh Chandra Paul**	Topological Superconductivity and Majorana Fermion in nanowire
Prof. S. Mukherjee	**Partha Paul**	Accelerated Detectors in dS/AdS space
Prof. A. Virmani	**Pratik Roy**	Cosmological Particle Creation
Prof. P. Agrawal	**Sujay Shil**	Production of Higgs by PP àt tbar H in LHC
Prof. S. Mandal	**Vijigiri Vikas**	Finding ground state of helical spin liquid on the Hollandite lattice

Mr. Pratik Roy was adjudged the most outstanding pre-doctoral scholar and was awarded the **L. K. Panda Memorial Fellowship** for the year 2014-15.

2.2 DOCTORAL PROGRAM

Presently Institute has presently thirty three doctoral scholars working in different areas under the supervision of its faculty members. Starting from 2009, all the scholars are registered with Homi Bhabha National Institute (HBNI), a deemed-to-be University within DAE. The progress of each doctoral scholar is reviewed annually by a review committee. This year the reviews are held in the months of July-August.

2.3 THESES

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

2.3.1. Thesis Submitted

1) **Ms. Sabita Das:** Thesis title: *Identified Particle Production and Freeze-out Dynamics in STAR at RHIC Beam Energy Scan Program*, Advisor: Prof. Sudhakar Panda Co-guide: Prof. Bedangadas Mohanty (NISER). Submitted on 31st March 2015.

2) **Mr. Somnath Bandyopadhyay:** Thesis Title: *Signatures of HIGGS BOSON through its production in Association with top pair*, Advisor: Prof. Pankaj Agrawal. Submitted on 30th Oct. 2014.

3) **Mr. Jim Chacko:** Thesis Tilte: *Interacting Systems Out-of-Equilibrium: Disordered ratchets, Molecular motors and Sandpiles,* Advisor: Prof. Goutam Tripathy. Submitted on 30th Oct. 2014.

2.3.2. Thesis Defended

1. Mr. Souvik Banerjee: Thesis title: *Going out of equilibrium in AdS/CFT,* Advisor: Prof. S. Mukherji. Thesis defended on 15th July 2014.

2. Mr. Raghavendra Rao Juluri: Thesis title: *Silver endotaxial nanostructures in Si and their SERS applications*, Advisor: Prof. P.V. Satyam. Thesis defended on 17th Oct. 2014.

3. Mr. S. K. Garg: Thesis title: *Patterning of Si surface by medium energy ion beams,* Advisor: Prof. T. Som. Thesis defended on 15th Nov. 2014.

4. Mr. Tanmoy Basu: Thesis title: *Ion-beam induced nanostructuring of silicon and its applications*, Advisor: Prof. T. Som. Thesis defendedon 3rd March 2015.

5. Mr. Abhishek Atreya : Thesis title: *Spontaneous CP violation in quark scattering from QCD Z(3) domains and its cosmological implications,* Advisor: Prof. A.M. Srivastava. Thesis defended on 16th March 2015.

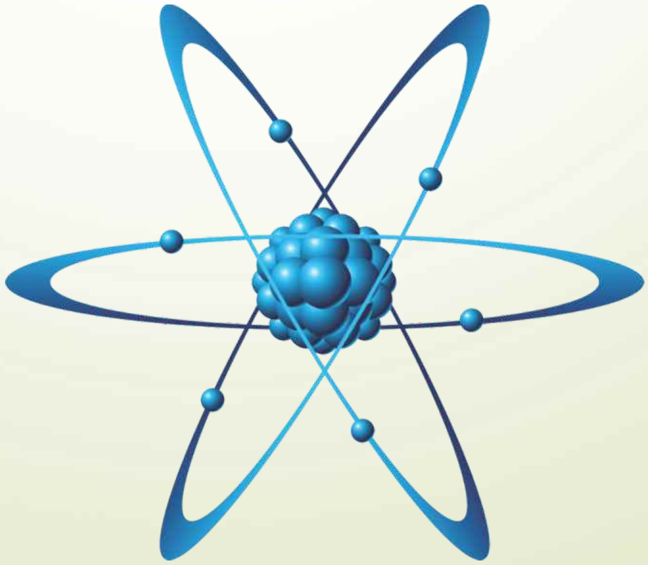
2.4 Summer Student's Visiting Program (SSVP) :

The motivation of the SSVP program is to expose the 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 7th May to 15th June, 2014. Ten students *was* participated in the program. Round trip train fare, accommodation on campus, and a monthly stipend of Rs.4500/- were provided to the visiting students. Under this program, each student worked under guidance of a faculty member of the Institute. At the end of the course, the students presented their work in a seminar on the assigned topics.

Name of the Student	Topic of the Seminar	Advisor
Abhipsa Mishra	Material characterisation with x-rays	Prof. P. V. Satyam
Ankit Patel	Semi-empirical mass formula for light nuclei	Prof. S. K. Patra
Debashree Das	The elementary algorithms in Quantum Computation	Prof. P. Agrawal
Neha Gupta	Imaging of nanostructures by SEM and FIB	Prof. P. V. Satyam
Pranaya Rath	MeV energetic ion beam implantation in Ge	Prof. T. Som
Sagarika Nayak	X-ray photoelectron spectroscopy	Prof. S. Varma
Suneha Rana	Quark Gluon Plasma	Prof. A. M. Srivastava
Trupti Ranjan Das	Ultraviolet photoelectron spectroscopy	Prof. B. R. Sekhar

3

RESEARCH



3.1 THEORETICAL CONDENSED MATTER PHYSICS

1. Single Particle Heat Engines

We have performed an extensive analysis of a single particle stochastic heat engine constructed by manipulating a Brownian particle in a time dependent harmonic potential. The cycle consists of two isothermal steps at different temperatures and two adiabatic steps similar to that of a Carnot engine. The engine shows qualitative differences in inertial and overdamped regimes. All the thermodynamic quantities, including efficiency, exhibit strong fluctuations in a time periodic steady state. The fluctuations of stochastic efficiency dominate over the mean values even in the quasistatic regime. Interestingly, our system acts as an engine provided the temperature difference between the two reservoirs is greater than a finite critical value which in turn depends on the cycle time and other system parameters. This is supported by our analytical results carried out in the quasistatic regime. Our system works more reliably as an engine for large cycle times. By studying various model systems we observe that the operational characteristics are model dependent. Our results clearly rules out any universal relation between efficiency at maximum power and temperature of the baths. We have also verified fluctuation relations for heat engines in time periodic steady state.

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

2. Extracting work from a single heat bath in presence of information

Work can be extracted from a single bath beyond the limit set by the second law by performing measurement on the system and utilising the acquired information. As an example we studied a Brownian particle confined in a two dimensional harmonic trap in presence of magnetic field, whose position co-ordinates are measured with finite precision. Two separate cases are investigated in this study - (A) moving the center of the potential and (B) varying the stiffness of the potential. Optimal protocols which extremise the work in a finite time process are explicitly calculated for these two cases. For Case-A, we show that even though the optimal protocols depend on magnetic field, surprisingly, extracted work is independent of the field. For Case-B, both the optimal protocol and the extracted work depend on the magnetic field. However, the presence of magnetic field always reduces the extraction of work.

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

3. Quantum transport via evanescent modes and possible device application

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

Sreemoyee Mukherjee, P. Singha Deo and A. M. Jayannavar.

4. Macrospin in external magnetic field: Entropy production and fluctuation theorems

We consider stochastic rotational dynamics of a single magnetic domain in an external magnetic field, at constant temperature. Starting from the appropriate Langevin equation of motion, we calculate entropy production along stochastic trajectories to obtain fluctuation theorems, by presenting several possibilities of choosing conjugate trajectories. One of these choices gives entropy production in the reservoir that is consistent with prediction from Fokker-Planck equation. We further show the relation between heat absorbed and entropy production in the reservoir, using stochastic energy balance. For a time-independent field, the magnetization obeys Boltzmann distribution, however, also supports an azimuthal current making the dynamics inherently non-equilibrium. We use numerical simulations to obtain distribution functions for entropy production along trajectories which show good agreement with the detailed fluctuation theorem.

Swarnali Bandopadhyay, Debasish Chaudhuri and A. M. Jayannavar

5. Derivation of the not-so-common fluctuation theorems

The detailed fluctuation theorems of the exact form P(A)/P(“A)=exp(A) exist only for a handful of variables A, namely for work (Crooks theorem), for total entropy change (Seifert’s theorem), etc. However, the so-called modified detailed fluctuation theorems can be formulated for several other thermodynamic variables as well. The difference is that the modified relations contain an extra factor, which is dependent on A. This factor is usually an average of a quantity exp(“B), where B`”A, with respect to the conditional probability distribution P(B|A). The corresponding modified integral fluctuation theorems also differ from their original counterparts, by not having the usual form è’exp(“A)é’=1. The generalization of these relations in presence of feedback has been discussed briefly. The results derived here serve to complement the already existing results in fluctuation theorems. The quantum version of these derivations have also been carried out

Sourabh Lahiri and A. M. Jayannavar

6. Effects of quenched disorder with qualitatively different behaviour of the steady state particle flux

We study the steady state properties of a system of particles interacting via hard core exclusion and moving in a discrete flashing disordered ratchet potential. Quenched disorder is introduced by breaking the periodicity of the ratchet potential through changing shape of the potential across randomly chosen but fixed periods. We show that the effects of quenched disorder can be broadly classified as strong or weak with qualitatively different behaviour of the steady state particle flux as a function of overall particle density. We further show that most of the effects including a density driven nonequilibrium phase transition observed can be understood by constructing an effective asymmetric simple exclusion process with quenched disorder in the hop rates.

G. Tripathy and Jim Chacko

3.2. THEORETICAL HIGH ENERGY PHYSICS

1. A path integral approach to the Langevin equation

We study the Langevin equation with both a white noise and a colored noise. We construct the Lagrangian as well as the Hamiltonian for the generalized Langevin equation which leads naturally to a path integral description from first principles. This derivation clarifies the meaning of the additional fields introduced by Martin, Siggia and Rose in their functional formalism. We show that the transition amplitude, in this case, is the generating functional for correlation functions. We work out explicitly the correlation functions for the Markovian process of the Brownian motion of a free particle as well as for that of the non-Markovian process of the Brownian motion of a harmonic oscillator (Uhlenbeck-Ornstein model). The path integral description also leads to a simple derivation of the Fokker-Planck equation for the generalized Langevin equation

Ashok K. Das, Sudhakar Panda, J.R.L. Santos

2. A note on low energy effective theory of chromo-natural inflation in the light of BICEP2 results

Recent result of BICEP2, revealing a larger value of tensor to scalar ratio (r), has opened up new investigations of the in ationary models to fit the experimental data. The experiment needs to reconfirm the results, specifically the consistency between Planck and BICEP2. On the other hand, the combined analysis of Planck and BICEP2 B, including the dust polarization uncertainty, brings down the upper limit on r. In this note, we reexamine the low energy effective theory of Chromo Natural In ation model and its generalization in view of such observational data. We find that the parameter space of the model admits a large value of r as well as other cosmological observables consistent with data.

Anindita Bhattacharjee, Atri Deshamukhya, Sudhakar Panda

3. Post-Planck Dark Energy Constraints

We constrain plausible dark energy models, parametrized by multiple candidate equation of state, using the recently published Cosmic Microwave Background (CMB) temperature anisotropy data from Planck together with the WMAP-9 low-l polarization data and data from low redshift surveys. To circumvent the limitations of any particular equation of state towards describing all existing dark energy models, we work with three different equation of state covering a broader class of dark energy models and, hence, provide more robust and generic constraints on the dark energy properties. We show that a clear tension exists between dark energy constraints from CMB and non-CMB observations when one allows for dark energy models having both phantom and non-phantom behavior; while CMB is more favorable to phantom models, the low-z data prefers model with behavior close to a Cosmological Constant. Further, we reconstruct the equation of state of dark energy as a function of redshift using the results from combined CMB and non-CMB data and find that Cosmological Constant lies outside the 1ó band for multiple dark energy models allowing phantom behavior. A considerable fine tuning is needed to keep models with strict non-phantom history inside 2ó allowed range. This result might motivate one to construct phantom models of dark energy,which is achievable in the presence of higher derivative operators as in string theory. However, disallowing phantom behavior, based only on strong theoretical prior, leads to both CMB and non-CMB datasets agree on the nature of dark energy, with the mean equation of state being very close to the Cosmological Constant. Finally, to illustrate the impact of additional dark energy parameters on other cosmological parameters, we provide the cosmological parameter constraints for different dark energy models.

Dhiraj Kumar Hazra, Subhabrata Majumdar, Supratik Pal, Sudhakar Panda, Anjan A. Sen

4. Relativistic Heavy-Ion Collisions

4.a. Quarkonium disintegration in relativistic heavy-ion collisions by CP violating Z(3) walls at finite temperature

In this work we extend our study of *J*/y disintegration due the Z(3) domain walls at finite temperatures. We incorporate the effects of Debye-screened potential on *J*/y wave function and study the enhancement in disintegration of *J*/y on interaction with the color field associated with a Z(3) wall.

Abhishek Atreya, Partha Bagchi, and Ajit M. Srivastava

4.b. Effect of confining forces on charge fluctuations in relativistic heavy ion collisions

We incorporate long range confining forces in the coalescence model and study its effects on the charge fluctuation observable for relativistic heavy-ion collision experiments.

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

4.c. Spontaneous CP violating quark scattering from asymmetric Z (3) interfaces in QGP

We extend our earlier study of spontaneous CP violating scattering of quarks and anti-quarks from QCD Z (3) domain walls for the situation when these walls have asymmetric profiles of the Polyakov loop order parameter *l(x)*. Dynamical quarks lead to explicit breaking of Z(3) symmetry, which lifts the degeneracy of the Z(3) vacua arising from spontaneous breaking of the Z(3) symmetry in the quark-gluon plasma (QGP) phase. Resulting domain walls have asymmetric profile of *l(x)* (under reflection $x \rightarrow -x$ *m* for a domain wall centered at the origin). We calculate the background gauge field profile A0 associated with this domain wall profile. Interestingly, even with the asymmetric *l(x)* profile, quark-antiquark scattering from the corresponding gauge field configuration does not reflect this asymmetry. We show that the expected asymmetry in scattering arises when we include the effect of asymmetric profile of *l(x)* on the effective mass of quarks and antiquarks and calculate resultant scattering. We discuss the effects of such asymmetric Z(3) walls in generating quark and antiquark density fluctuations in cosmology, and in relativistic heavy-ion collisions e.g. event-by-event baryon fluctuations.

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

4.d. Quarkonia Disintegration due to time dependence of the $q\bar{q}$ potential in Relativistic Heavy Ion Collisions

Rapid thermalization in ultra-relativistic heavy-ion collisions leads to fast changing potential between a heavy quark and antiquark from zero temperature potential to the finite temperature one. Time dependent perturbation theory can then be used to calculate the survival probability of the initial quarkonium state. In view of very short time scales of thermalization at RHIC and LHC energies, we calculate the survival probability of J/ψ and Υ using sudden approximation. Our results show that quarkonium decay may be significant even when temperature of QGP remains low enough so that the conventional quarkonium melting due to Debye screening is ineffective.

P. Bagchi and A. M. Srivastava

4.e. Disintegration of quarkonia in Thermal Medium due to QCD Z(3) interfaces in Relativistic Heavy Ion Collisions

In this work we discuss the possibility of prompt as well as thermal heavy Quarkonia disintegration due to the Z(3) domain walls that are expected to form in QGP medium. Here by modeling the dependence of effective mass of the quarks on the Polyakov loop order parameter, we study the interaction of Upsilon with Z(3) interfaces which disintegrates Quarkonia by exciting it to higher states of $q\bar{q}$ system which are supposed to be short-lived in medium.

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

4.f. Reaction diffusion equation for quark-hadron transition in heavy-ion collisions

Reaction diffusion equations with suitable boundary conditions have special propagating solutions which very closely resemble the moving interfaces in a first order transition. We show that the dynamics of chiral order parameter for chiral transition in heavy-ion collisions is governed by one such equation, specifically, the Newell-Whitehead equation. Further, required boundary conditions are automatically satisfied due to the geometry of the collision. The chiral transition is, therefore, completed by a propagating interface, exactly as for a first order transition, even though the transition actually is a crossover. Same thing also happens when we consider confinement-deconfinement transition with Polyakov loop order parameter. We discuss the implications of this results for heavy-ion collisions. We also discuss possible applications for the case of early universe.

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

5. Cosmology

5.a. AdS/CFT and deSitter space

Using AdS/CFT prescription, we compute two point Yang-Mills correlator on a constant time slice for the Kasner background. Pushing the surface close to the initial singularity, we find, in some cases, the correlator does not develop pole. This is consistent with the observations made in a recent work. We further numerically calculate similar correlator where the bulk is a Kasner AdS soliton. We find that the qualitative behaviour of the correlator remains unchanged.

S. Mukherji, S. Banerjee, S. Bhowmick and S. Chatterjee

5.b.. Gauge/gravity duality:

Within gauge/gravity duality, taking cosmological constant as a thermodynamic variable in the bulk amounts to including colour degrees of freedom in the extended thermodynamic phase spase at the boundary. This allow us to introduce a chemical potential conjugate to the colour. We show that for the Gauss-Bonnet black hole, unlike the Schwarzchild in AdS, the chemical potential changes sign in the stable black hole phase as we change the hole's horizon radius. This zero of the chemical potential may signal a Bose-like (colour) condensate in the decon_ning phase of the strongly coupled gauge theory

S. Mukherji, and B. Chandrasekhar

5.c. Effects of Phase Transition induced density fluctuations on pulsar Dynamics

We show that density fluctuations during phase transitions in pulsar cores may have non-trivial effects on pulsar timings, and may also possibly account for glitches and anti-glitches. These density fluctuations invariably lead to non-zero off-diagonal components of the moment of inertia, leading to transient wobbling of star. Thus, accurate measurements of pulsar timing and intensity modulations (from wobbling) may be used to identify the specific pattern of density fluctuations, hence the particular phase transition, occurring inside the pulsar core. Changes in quadrupole moment from rapidly evolving density fluctuations during the transition, with very short time scales, may provide a new source for gravitational waves.

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

5.d. Probing Dynamics of Phase Transitions occurring inside a Pulsar

During the evolution of a pulsar, various phase transitions may occur in its dense interior, such as superfluid transition, as well as transition to various exotic phases of quantum chromodynamics (QCD). We propose a technique which allows to probe these phases and associated transitions by detecting changes in rotation of the star arising from density changes and fluctuations during the transition affecting star's moment of inertia. Our results suggest that these changes may be observable, and may possibly account for glitches and (recently observed) anti-glitches. Accurate measurements of pulsar timing and intensity modulations (arising from wobbling of star due to development of the off-diagonal components of moment of inertia) may be used to pin down the particular phase transition occurring inside the pulsar core. We also discuss the possibility of observing gravitational waves from the changes in the quadrupole moment arising from these rapidly evolving density fluctuations.

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

6. Liquid Crystal Experiments String percolation due to multiple heat sources in liquid crystals

We are developing a system of liquid crystal sample with multiple beads which will be heated up using infra-red heater. The beads will heat up NLC locally above the isotropic phase transition leading to formation of network of strings which will expand due to convective flow. The strings from different beads will intercommute leading to percolating network. This system simulated formation of infinite string network in the early universe due to multiple black holes evaporating in a plasma background.

Ajit M. Srivastava

7. Gluon fusion contribution to V H j production at hadron colliders

We study the associated production of an electroweak vector boson and the Higgs boson with a jet via gluon-gluon fusion. At the leading order, these processes occur at one-loop level. The amplitudes of these one-loop processes are gauge invariant and finite. Therefore, their contributions towards the corresponding hadronic cross sections and kinematic distributions can be calculated separately. We present results for the Large Hadron Collider and its discussed upgrades. We find that the gluon-gluon one-loop process gives dominant contribution to the Z H j production. We observe a destructive interference effect in the gg Z H j amplitude. We also find that in the high transverse momentum and central rapidity region, the Z H j production cross section via gluon-gluon fusion becomes comparable to the cross section contributions coming from quark-quark and quark-gluon channels

P. Agrawal and Ambresh Shivaji

8. **Multilepton and Multijet Signatures of the Higgs Boson with bottom and tau-jet tagging**

We consider the possible production of the Higgs Boson in association with a top-quark pair and its subsequent decay into a tau-lepton pair, or a W-boson pair, or a bottom-jet pair. This process and decay chains can give rise to many signatures of the Higgs boson. These signatures can have electrons, muons, tau jets, bottom jets and/or light avour jets. We are analyzing the viability of some of these signatures. Earlier we had explored, two, three and four-lepton signatures. We have now analysed a single lepton + jets and multi-jet signatures. In the former case, it appears to be necessary to tag three tau-jets. In the case of multijet signatures, four tau-jets needs to be tagged. Bottom jet tag also helps. We show that some of these signatures may be visible in run II of the Large Hadron Collider (LHC). Some of the other signatures would also be observable after the LHC accumulates sufficient luminosity.

P. Agrawal and Siba P. Das

9. Geroch Group Description of Black Holes

On one hand the Geroch group allows one to associate spacetime independent matrices with gravitational configurations that effectively only depend on two coordinates. This class includes stationary axisymmetric four- and five-dimensional black holes. On the other hand, a recently developed inverse scattering method allows one to factorize these matrices to explicitly construct the corresponding spacetime configurations. In this work we demonstrate the construction as well as the factorization of Geroch group matrices for a wide class of black hole examples. In particular, we obtain the Geroch group SL(3,R) matrices for the five-dimensional Myers-Perry and Kaluza-Klein black holes and the Geroch group SU(2,1) matrix for the four-dimensional Kerr-Newman black hole. We also present certain non-trivial relations between the Geroch group matrices and charge matrices for these black holes.

Bidisha Chakrabarty, Amitabh Virmani

10. An Inverse Scattering Construction of the JMaRT Fuzzball

We present an inverse scattering construction in STU supergravity of the two-charge single-rotation JMaRT fuzzball. The key element in our construction is the fact that with appropriate changes in the parameters, the JMaRT fuzzball can be smoothly connected to the Myers-Perry instanton.

Despoina Katsimpouri, Axel Kleinschmidt, Amitabh Virmani

11. Non-supersymmetric Microstates of the MSW System

We present an analysis parallel to that of Giusto, Ross, and Saxena (arXiv:0708.3845) and construct a discrete family of non-supersymmetric microstate geometries of the Maldacena-Strominger-Witten system. The supergravity configuration in which we look for the smooth microstates is constructed using SO(4,4) dualities applied to an appropriate seed solution. The SO(4,4) approach offers certain technical advantages. Our microstate solutions are smooth in five dimensions, as opposed to all previously known non-supersymmetric microstates with AdS3 cores, which are smooth only in six dimensions. The decoupled geometries for our microstates are related to global AdS3 x S2 by spectral flows.

Souvik Banerjee, Borun D. Chowdhury, Bert Vercnocke, Amitabh Virmani

12. A procedure for application of T-duality

Transformation on scattering amplitudes of closed bosonic stringy states. These states arise due to compactification of closed string to lower spacetime dimensions through dimensional reduction. The amplitude, in the first quantized formalism, is computed by introducing vertex operators. The amplitude is constructed by the standard prescription and the vertex operators are required to respect conformal invariance. Such vertex operators are constructed in the weak field approximation. Therefore, the vertex operators of the stringy states of our interest are to be defined accordingly. We propose a prescription to implement T-duality on the three point functions and N-point functions. We argue that it is possible to generate new amplitudes through the transformations on a given amplitude just as T-duality transformations can take us to a new set of string vacuum when acted upon an initial set. Explicit examples are given for three point and four point functions.

J. Maharana

13. Enhancing sensitivity to neutrino parameters at INO combining muon and hadron information

The proposed ICAL experiment at INO aims to identify the neutrino mass hierarchy from observations of atmospheric neutrinos, and help improve the precision on the atmospheric neutrino mixing parameters. While the design of ICAL is primarily optimized to measure muon momentum, it is also capable of measuring the hadron energy in each event. Although the hadron energy is measured with relatively lower resolution, it nevertheless contains crucial information on the event, which may be extracted when taken concomitant with the muon data. We demonstrate that by adding the hadron energy information to the muon energy and muon direction in each event, the sensitivity of ICAL to the neutrino parameters can be improved significantly. Using the realistic detector response for ICAL, we present its enhanced reach for determining the neutrino mass hierarchy, the atmospheric mass squared difference and the mixing angle θ_{23}, including its octant. In particular, we show that the analysis that uses hadron energy information can distinguish the normal and inverted mass hierarchies with $\Delta\chi^2 \approx 9$ with 10 years exposure at the 50 kt ICAL, which corresponds to about 40% improvement over the muon-only analysis.

Moon Moon Devi, Tarak Thakore, Sanjib Kumar Agarwalla, Amol Dighe

14. Probing Neutrino Oscillation Parameters using High Power Superbeam from ESS

A high-power neutrino superbeam experiment at the ESS facility has been proposed such that the source-detector distance falls at the second oscillation maximum, giving very good sensitivity towards establishing CP violation. In this work, we explore the comparative physics reach of the experiment in terms of leptonic CP-violation, precision on atmospheric parameters, non-maximal θ_{23}, and its octant for a variety of choices for the baselines. We also vary the neutrino vs. the anti-neutrino running time for the beam, and study its impact on the physics goals of the experiment.

Sanjib Kumar Agarwalla, Sandhya Choubey, Suprabh Prakash

15. Probing Non-Standard Interactions at Daya Bay

In this article we consider the presence of neutrino non-standard interactions (NSI) in the production and detection processes of reactor antineutrinos at the Daya Bay experiment. We report for the first time, the new constraints on the flavor non-universal and flavor universal charged-current NSI parameters, estimated using the currently released 621 days of Daya Bay data. New limits are placed assuming that the new physics effects are just inverse of each other in the production and detection processes.

Sanjib Kumar Agarwalla, Partha Bagchi, David V. Forero, Mariam Tortola

16. New Power to Measure Supernova ν_e with Large Liquid Scintillator Detectors

We examine the prospects for detecting supernova ν_e in JUNO, RENO-50, LENA, or other approved or proposed large liquid scintillator detectors. The main detection channels for supernova ν_e in a liquid scintillator are its elastic scattering with electrons and its charged-current interaction with the ^{12}C nucleus. In existing scintillator detectors, the numbers of events from these interactions are too small to be very useful. However, at the 20-kton scale planned for the new detectors, these channels become powerful tools for probing the ν_e emission.

Ranjan Laha, John F. Beacom, Sanjib Kumar Agarwalla

3.3. THEORETICAL NUCLEAR PHYSICS

1. Gravitational wave strain amplitude from rotating compact neutron star

Using the nuclear equation of states for a large variety of relativistic and non-relativistic force parameters, we calculate the masses and radii of neutron stars. From these equation of states, we also evaluate the properties of rotating neutron stars, such as rotational and gravitational frequencies, moment of inertia, quadrupole deformation parameter, rotational ellipticity and gravitational wave strain amplitude. The estimated gravitational wave strain amplitude of the star is found to be in the range $10^{-22} \sim 10^{-24}$.

S. K, Patra and Collaborators

2. Cluster radioactive-decay using the relativistic mean field theory within the preformed cluster model

We have studied the (ground-state) cluster radioactive-decays using for the first time in the relativistic mean field (RMF) theory within the preformed cluster model (PCM) of Gupta and collaborators. Following the PCM approach, we have deduced empirically the preformation probability P_0^{emp} from the experimental data on both the á and exotic cluster-decays, specifically of parents in the translead region having doubly magic ^{208}Pb or its neighboring nuclei as daughters. Interestingly, the RMF theory supports the concept of preformation for both the á and heavier clusters in radioactive nuclei. for alpha-decays is almost constant ~ $10^{-2} – 10^{-3}$ for all the parent nuclei considered here, and for cluster-decays of the same parents decrease with the size of clusters emitted from di_erent parents. The results obtained for are reasonable, and are within two to three orders of magnitude of the well accepted phenomenological model of Blendowske-Walliser for light clusters.

S. K, Patra and Collaborators

3. Giant resonances for drip-line nuclei

We analyze the in uence of the density dependence of the symmetry energy on the average excitation energy of the isoscalar giant monopole resonance (GMR) in stable and exotic neutron-rich nuclei by applying the relativistic extended Thomas-Fermi method in scaling and constrained calculations. For the active nuclear interaction, we employ the relativistic mean field model supplemented by an isoscalar-isovector meson coupling that allows one to modify the density dependence of the symmetry energy without compromising the success of the model for binding energies and charge radii. The semiclassical estimates of the average energy of the GMR are known to be in good agreement with the results obtained in full RPA calculations. The present analysis is performed along the Pb and Zr isotopic chains. In the scaling calculations, the excitation energy is larger when the symmetry energy is softer. The same happens in the constrained calculations for nuclei with small and moderate neutron excess. However, for nuclei of large isospin the constrained excitation energy becomes smaller in models having a soft symmetry energy. This effect is mainly due to the presence of loosely-bound outer neutrons in these isotopes. A sharp increase of the estimated width of the resonance is found in largely neutron-rich isotopes, even for heavy nuclei, which is enhanced when the symmetry energy of the model is soft. The results indicate that at large neutron numbers the structure of the low-energy region of the GMR strength distribution changes considerably with the density dependence of the nuclear symmetry energy, which may be worthy of further characterization in RPA calculations of the response function.

S. K, Patra and Collaborators

4. Nuclear reaction

We calculate the nuclear reaction cross-sections of exotic nuclei in the framework of the Glauber model, using as inputs the standard realativistic mean field (RMF) densities and the densities obtained from the more recently developed effective field theory motivated RMF (E-RMF). Both light and heavy nuclei are taken as the representative targets and light neutron-rich nuclei as projectiles. We find the increase of nuclear reaction cross-section as a function of mass number for both the target and projectile. For a further application of the method, we suggest a mechanism for the formation of superheavy and highly neutron-rich elements in astrophysical objects. For explaining this mechanism, we have used the nuclear fusion cross-sections obtained from the non-relativistic coupled channel calculations.
For the astrophysical application, here we calculate the reaction and the fusion cross-

sections of neutron-rich heavy nuclei taking light exotic isotopes as projectiles. Results of neutron-rich Pb and U isotopes are demonstrated as the representative targets and He, B as the projectiles. The Gluaber Model and the Coupled Channel Formalism are used to evaluate the reaction and the fusion cross-sections for the cases considered. Based on the analysis of these cross-sections, we predict the formation of heavy, superheavy and supersuperheavy elements through rapid neutron/light nuclei capture r-process of the nucleosynthesis in astrophysical objects. We calculate the one neutron removal reaction cross sections (ó $_{-1n}$) for some stable and neutron-rich halo nuclei with ^{12}C as target, using relativistic mean field (RMF) densities in the frame work of the Glauber model. The results are compared with the experimentally measured data. Studies of stable nuclei with deformed densities have shown a good agreement with the data, however, it differs significantly for halo nuclei cases. Estimating the ó $_{-1n}$ value from the difference of reaction cross-section of two neighboring nuclei with mass number A and that of A-1 in an isotopic chain, we get good agreement with the known experimental data for halo cases.

S. K, Patra and Collaborators

5. K Isomers in neutron-rich Rare-earth nuclei

Two and four quasiparticle K isomeric configurations in even mass Sm, Gd, Dy, Er, Yb nuclei have been studied along with the ground and other lowlying bands. The intrinsic states are obtained by deformed Hartree-Fock calculation and the spectra and electromagnetic properties have been obtained by angular momentum projection. Comparison with known experimental spectra and electromagnetic moments are made.

C. R. Praharaj

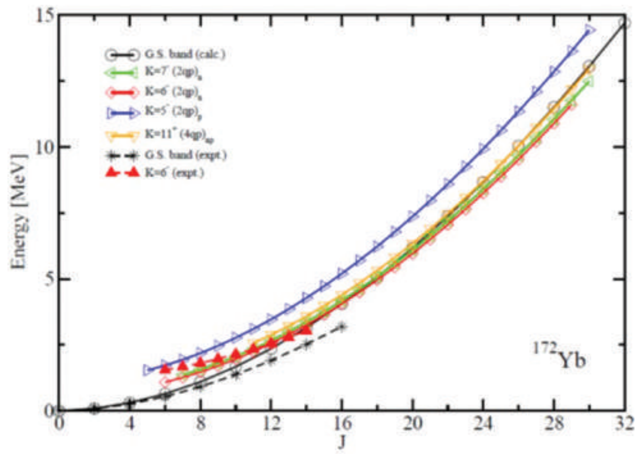


Figure 1: Bands and K Isomers in 172Yb

2. Nuclear Structure of Double Beta Decay Nuclei in A = 70 " 130 region

Nuclear structure of nuclei in the mass region A = 76 to A = 130, are studied in the framework of the self-consistent deformed Hartree-Fock (HF) and angular momentum (J) projection model using Surface Delta residual interaction. Spectra of ground bands have been studied and compared with available experimental results for even-even and odd-odd nuclei involved in double beta decay. To test the reliability of the wave functions we have also calculated the reduced E2 transition matrix elements, electric quadrupole moments and magnetic dipole moments for these nuclei. The calculated results are compared with the experimental findings and substantial agreement is achieved.

Nuclear transition matrix elements for Double Beta Decay are computed and compared with available experimental results as well as other theoretical model calculations.

C. R. Praharaj

6. Rotational Bands and K Isomers in Hafnium nuclei

The structure and rotational bands of even mass $^{168"176}$Hf nucleus are studied in the framework of deformed Hartree-Fock formalism using surface delta interaction for protons and neutrons in the $sdg_{7/2}h_{11/2}$ space (protons) and $fph_{9/2}i_{13/2}$ space (neutrons). The ground band, RAL band due to rotation-alignment of $i_{13/2}$ neutrons and the interaction of these two bands along with the excited large K bands are investigated. The B(E2) values are also given and compared with the available experimental data.

C. R. Praharaj

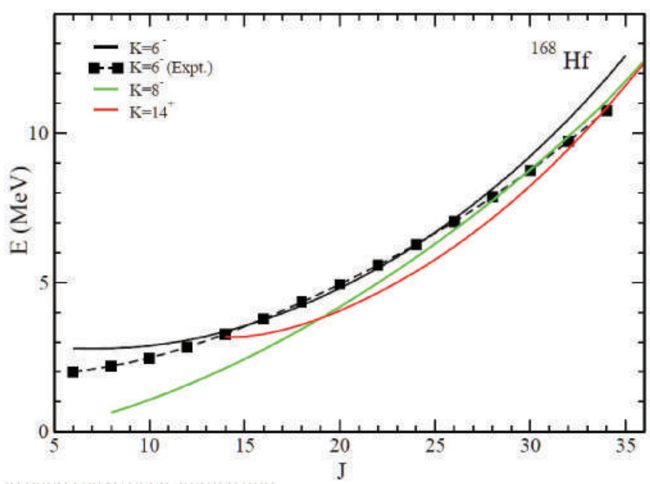


Figure 2: Comparison between experimental and theoretical spectra of 168Hf

3.4. HIGH ENERGY NUCLEAR PHYSICS

1. Heavy-ion collisions at LHC, RHIC and CBM:

The strongly decaying particles having lifetime (ô) of the order of 10^{-23} sec are called resonances. It carries a set of quantum numbers, spin, isospin, etc. It differs from regular particles by its mass smeared and a width. This is based on uncertainty principle between time and energy which implies shorter the life time, the wider is the uncertainty in mass. In heavy ion collisions, during the expansion of the fireball, a stage is reached where the inelastic interactions among hadrons cease and this is known as the chemical freeze-out. Kinetic freeze-out is reached where there is no further elastic interactions among the produced hadrons. Since the resonances have very short life times (<" few fm/c), a fraction of them decay inside the medium before the thermal freeze-out. In such a case the hadronic decay daughter particles go through a period of elastic interactions with the hadrons in the medium. These interactions alter the momenta of the daughter particles. However, after the chemical freeze-out, there can be pseudo-inelastic interactions among the hadrons in the medium, resulting in an increase in the resonance population. Therefore, both the resonance regeneration and primary production contribute to the total yield of resonance signals detected. Measurement of the resonance yields can therefore serve as a tool to probe the time evolution of the system (from thermal to kinetic freeze-out) and to study the final state interactions in the hadronic medium.

The analysis note presents the results of transverse momentum spectra measurement of Delta star (1520) from p-p collisions at 7 TeV energy at mid rapidity with the ALICE detector at LHC. This analysis is also performed to create the base line for future p-Pb and Pb-Pb analysis. Here the main focus will be on the signal in low and intermediate transverse momentum region (pT <5.5GeV /c)

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

2. The Relativistic Heavy Ion Collider (RHIC) at Brookhaven National

Laboratory (BNL) is primarily designed to study the properties of a new state of matter, called the Quark Gluon Plasma (QGP). The Beam Energy Scan (BES) program at RHIC is devoted to study the QCD phase diagram which involves searching for the possible QCD phase boundary and the possible QCD critical point. The STAR experiment has collected data for Au+Au collisions at 7.7, 11.5 and 39 GeV energies in the year 2010. The chemical and kinetic freeze-out parameters can be extracted from the experimentally measured yields of identified hadrons within the framework of thermodynamical models. At the chemical freeze-out, no further inelastic collisions between particles occur and the particle composition is fixed. When elastic collisions between particles also cease, the kinetic freeze-out takes place. These freeze-out parameters provide information about the system at different stages of the expansion.

We have studied the centrality dependence of freeze-out parameters for Au+Au collisions at mid-rapidity for 7.7, 11.5, and 39 GeV energies. The chemical freeze-out parameters are obtained by comparing the measured particle ratios to those from the statistical thermal model (THERMUS) calculations. This model assumes thermal and chemical equilibrium. The main fit parameters are chemical freeze-out parameter T_{ch} , baryonic chemical potential μ_B strangeness chemical potential μ_S , and strangeness suppression factor S . The grand-canonical ensemble (GCE) approach is used to fit the experimental particle ratios and to obtain the chemical freeze-out parameters. The extracted T_{ch} increases with increasing energy and also shows a slight increase as we go from peripheral to central collisions for all energies. The μ_B increases with decreasing energy. This is because of large baryon stopping at mid-^rapidity at low energies. The μ_B also shows a slight increase from peripheral to central collisions for these energies.

We also analyze the strangeness particles (Ks, ,Î and Ù) in STAR experiment. Strangeness enhancement in heavy ion collisions at p+p collision, allow us in the confirmation of de-confined quark gluon phase, a state of matter believed to exist at sufficiently high energy densities. We have performed invariant mass distribution and raw spectra of Ks, in Au+Au collision with center of mass energy 19.6GeV and efficiency has been corrected. Then we opt for Î and Ù particle reconstruction.

For STAR Collaboration: S. Das, S. K. Tripathy and P. K. Sahu

3. Development of the GEM detector prototype for the ALICE TPC upgrade

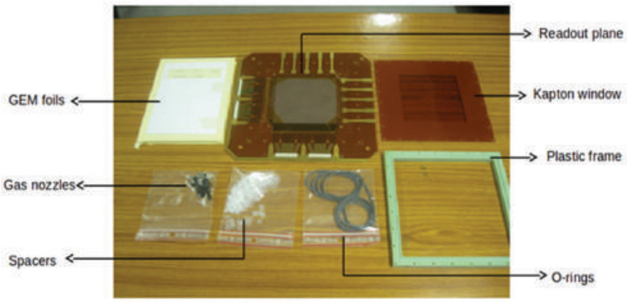


Fig.1 Components of a triple GEM detector.

Fig.1 Components of a triple GEM detector.

Gas Electron Multiplier (GEM) is one of the most important micro-pattern gaseous detectors used in the recent and being considered for future High-Energy Physics (HEP) experiments [1, 2]. For example ALICE at the Large Hadron Collider Facility is upgrading its multi-wire proportional chamber based Time Projection Chamber (TPC) with GEM units. In line with the worldwide efforts, we have also taken an initiative in our experimental high-energy physics detector laboratory build and test of GEM detector prototypes. The GEM foils and other components are obtained from CERN (shown in Fig. 1).

One GEM detector prototype is built in this lab with drift gap; two transfer gaps and induction gap as 3, 2, 2, 2 mm respectively, keeping ALICE experiment in mind [3]. The complete detector is shown in Fig.2. The leak test of the detector is done by water manometer [4]. The voltage divider of the detector is made and is tested with a gas mixture of Argon/CO_2 of 70/30-volume ratio with Co^{60}, Cs^{137} and Sr^{90} radioactive sources. The detector worked successfully. The count rate of the detector depends on the gas flow rate and it is optimized. This is because due to increase of gas flow rate the gain of the detector increases if there is leak in the detector somewhere. Because increasing gas flow rate the electronegative O_2 content decreases. On the other hand increasing gas flow rate further the pressure increases which decreases the gain. When this two effects work simultaneously then an optimum flow rate is observed which gives the maximum gain.

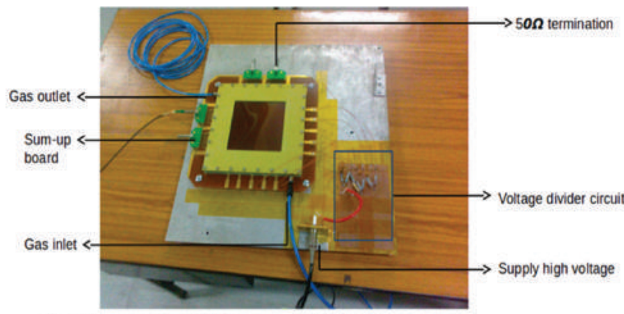


Fig.2 The complete GEM detector with HV divider.

Fig.2 The complete GEM detector with HV divider

The Long-term stability test of this 10 cm x 10 cm single mask triple GEM is performed using Sr 90 beta radioactive source. No ageing is observed even after operation of the GEM detector for about 325 hours or after an accumulation of charge per unit area of about 0.05 mC/cm2. This result is very essential for ALICE experiment. The temperature and atmospheric pressure has been measured and recorded continuously using a data logger developed in-house [5]. The data logger has been developed to monitor and record the ambient parameters such as temperature, relative humidity and pressure. With this data logger continuous recording of t, p, RH and time stamp can be done with a programmable sampling interval. This data is necessary to correct the gain of a gas filled detector.

S. Biswas, P. Bhattacharya, B. Mohanty, P. K. Sahu and S. Sahu

4. Nuclear astrophysics and nuclear equation of state:

Recent observation of pulsar PSR J1614-2230 with mass about 2 solar mass had indeed posed a severe constraint on the equations of state (EOS) of matter describing stars under extreme conditions. Compact stars can have hadronic matter, neutron stars (NSs), or can have exotic states of matter like strange quark matter, strange stars (SSs), or color superconducting matter. Stars also can have a quark core surrounded by hadronic matter, known as hybrid stars (HSs). The HS is likely to have a mixed phase region in between. Observational results also suggest huge surface magnetic field in certain NSs called magnetars. NSs can reach the mass limits set by PSR J1614-2230. But stars having hyperons or quark stars (QSs) having boson condensates, having softer EOS can barely reach such limits and are ruled out. QS with pure strange matter, can barely have such huge masses unless the effect of strong coupling constant or color superconductivity are taken into account.

We have studied the effect of strong magnetic field on the EOSs of matter under extreme condition. We also have studied the hadron-quark phase transition in the interiors of NS giving rise to hybrid stars (HS) with strong magnetic field. The hadronic matter EOS is described by GM1 parameter set. For the quark phase we use the simple MIT bag model. We have included the effect of strong magnetic fields leading to Landau quantization of the charged particles. We construct the intermediate mixed phase region, using Glendenning construction and enforcing Gibbs criterion. We assume density dependent bag pressure and magnetic field. The magnetic field strength increases going from the surface to the center of the star. We find that the magnetic field softens the EOS of both the matter phases. The effect of magnetic field is insignificant unless the field strength is above 10^{14} G. A varying magnetic field, with surface field strength of 10^{14} G and the central field strength of the order of 10^{17} G has significant effect on both the stiffness and the mixed phase regime of the EOS. We have also studied the mass-radius relationship for such type of mixed HS, and calculate their maximum mass, and compared them with the recent observation of PSR J1614-2230. HS with a mixed phase region cannot reach the mass limit set by PSR J1614-2230 unless we assume a low density dependent bag constant. For such a case the mixed phase region is truncated and their is a jump in the EOS curve going from the mixed phase to the quark phase. The maximum mass of a mixed hybrid star obtained with such mixed phase region is 1.98 M_{solar}.

As the state of matter of the resultant SS/HS is different from the initial hadronic matter, their masses also differ. Special theory of relativity relates mass to energy. Therefore, such conversion leads to huge energy release, sometimes of the order of 1053 ergs. In the present work we study the qualitative energy released by such conversion. Recent observations reveal huge surface magnetic field found in certain stars, now called magnetars. Such huge magnetic fields can modify the equations of state (EOS) of the matter describing the star. Therefore, the mass of magnetars are different from normal NS. The energy released during the conversion process from neutron magnetar (NM) to strange magnetar/hybrid magnetar (SS/HS) is different from normal NS to SS/HS conversion. In this work we calculate the energy release during the phase transition in magnetars. The energy released during NS to SS/HS conversion exceeds the energy released during NM to SM/HM conversion. The energy released during the conversion of NS to SS is always of the order of 10^{53} ergs. The amount of energy released during such conversion can only be compared to the energy observed during the gamma ray bursts (GRB). The energy liberated during NM to HM conversion is of the order of 10^{52} ergs, and is not likely to power GRB at cosmological distances. However, the magnetars are more likely to lose their energy from the magnetic poles and can produce giant flares, which are usually associated with magnetars.

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

5. Proton decay and new contribution to neutrino-less double beta decay in SO(10) with low-mass Z-prime boson, observable n-nbar oscillation, lepton flavor violation, and rare kaon decay

Conventionally for observable $n-\bar{n}$ oscillation through Pati-Salam intermediate gauge symmetry in *SO(10)*, the canonical seesaw mechanism is also constrained by $M_R \sim M_C$ d" 10^6 GeV which yields light neutrino masses much larger than the neutrino oscillation data. Recently, this difficulty has been evaded via inverse seesaw mechanism, but with proton lifetime far beyond the experimentally accessible limits. In the present work, adopting the view that we may have only a TeV scale $\acute{Z}$ gauge boson, we show how a class of non-SUSY *SO(10)* models allow experimentally verifiable proton lifetime and the new contributions to neutrinoless double beta decay in the W_L-W_L channel, lepton flavor violating branching ratios, observable oscillation, and lepto-quark gauge boson mediated rare kaon decays. The occurrence of Pati-Salam gauge symmetry with unbroken D-parity and two gauge couplings at the highest intermediate scale guarantees precision unification in such models. This symmetry also ensures vanishing GUT threshold uncertainy on or on the highest intermediate scale. Although the proton lifetime prediction is brought closer to the ongoing search limits with GUT threshold effects in the minimal model, no such effects are needed in a non-minimal model. We derive a new analytic expression for the 0νββ decay half-life and show how the existing experimental limits impose the lower bound on the lightest of the three heavy sterile neutrino masses, GeV. We also derive a new lower bound on the lepto-quark gauge boson mass mediating rare kaon decay, M_{lepto} e" 1.53 ±0.06 × 10^6 GeV. The mixing times are predicted in the range sec.

M. K. Parida, R. L. Awasthi and P. K. Sahu

3.5. QUANTUM INFORMATION

1. Quantum Discord has local and nonlocal quantumness

It has been suggested that there may exist quantum correlations that go beyond entanglement. The existence of such correlations can be revealed by quantum discord, but not by the conventional measure of entanglement. We argue that a state displays quantumness that can be of local and nonlocal origin. The physical quantity such as the quantum discord probes not only the nonlocal quantumness but also the local quantumness, such as the \local superposition". This can be a reason why such measures are non-zero when there is no entanglement. We consider a generalized version of the Werner state to demonstrate the interplay of local quantumness, nonlocal quantumness, and classical mixedness of a state.

P. Agrawal, Indranil Chakrabarty, Sk Sazim, and Arun K. Pati

2. More Communication with Less Entanglement

We exhibit the intriguing phenomena of \Less is More" using a set of multipartite entangled states. We consider the quantum communication protocols for the exact teleportation, superdense coding, and quantum key distribution. We find that sometimes less entanglement is more useful. To understand this phenomena we obtain a condition that a resource state must satisfy to communicate a n-qubit pure state with m terms. We find that the an appropriate partition of the resource state should have a von-Neumann entropy of log2m. Furthermore, it is shown that some states may be suitable for exact superdense coding, but not for exact teleportation.

P. Agrawal, Satyabrata Adhikari and Sumit Nandi

3. Bell-Type Inequalities Can Act as a Measure of Entanglement

We study local-realistic inequalities, Bell-type inequalities, for finite dimensional quantum Systems – qudits. There are a number of proposed Bell inequalities for such systems. Our interest is in relating the value of Bell inequality function with a measure of entanglement. Interestingly, we find that one of these inequalities, Son-Lee-Kim inequality can be used to easure entanglement of a pure bipartite state. We also discuss the experimental feasibility of this measurement.

P. Agrawal, Chandan Datta and Sujit Choudhary

4. Quantumness Vector: An Approach To Characterize Quantumness of Multiqubit Quantum states

We have distinguished two types of quantumness of a state – local and nonlocal. The nonlocal quantumness corresponds to entanglement. There are a number of measures in the literature that attempt to characterize the entanglement, or quantum correlations beyond entanglement". Usually such characterization is done using only one number. We emphasize the need to use a vector quantity to characterize the complex quantum nature of a multipartite state. We do so using multivariate mutual information. We have generalized the notion of dissension to n-qubit states. We have introduced two types of dissensions - Track 1 and Track 2. Using these vector measures, one can characterize n-qubit states with various forms of classicality and quantumness. We also point out that though dissension can be negative, it is not a weakness. The dissension has to be negative for certain type of quantum correlations.

P. Agrawal and Sk. Sazim

5. **Commutativity and Correlations**

We have explored the possibility of using commutativity of the observables with a density matrix to quantify the classical and quantum correlations of the quantum state. It turns out
that by computing covariance of a suitable set of operators and appropriately minimizing and maximizing a covariance based quantity, one can characterize and quantify classical and quantum correlations. The connections are still being explored.

P. Agrawal, Sujit Choudhary and Ujjwal Sen

6. Ontological Models, Preparation Contextuality and Nonlocality

The ontological model framework for an operational theory has generated much interest in recent years. The debate concerning reality of quantum states has been made more precise in this framework. With the introduction of generalized notion of contextuality in this framework, it has been shown that completely mixed state of a qubit is preparation contextual. Interestingly, this new idea of preparation contextuality has been used to demonstrate nonlocality of some ψ-epistemic models without any use of Bell's inequality. In particular, nonlocality of a non maximally ψ-epistemic model has been demonstrated from preparation contextulity of a maximally mixed qubit and Schrödinger's steerability of the maximally entangled state of two qubits. In the present work, we have first shown that any mixed state is preparation contextual. We have then shown that nonlocality of any bipartite pure entangled state, with Schmidt rank two, follows from preparation contextuality and steerability provided we impose certain condition on the epistemicity of the underlying ontological model. More interestingly, if the pure entangled state is of Schmidt rank greater than two, its nonlocality follows without any further condition on the epistemicity. Thus our result establishes a stronger connection between nonlocality and preparation contextuality by revealing nonlocality of any bipartite pure entangled states without any use of Bell-type inequality.

M. Banik, S. S. Bhattacharya, Sujit K. Choudhary, A. Mukherjee, A. Roy

7. Leggett-Garg Inequality and Device-independent randomness

Leggett-Garg inequalities (LGI) are constraints on certain combinations of temporal correlations obtained by measuring one and the same system at two different instants of time. The usual derivations of LGI assume macroscopic realism per se and noninvasive measurability. We have derived these inequalities under a different set of assumptions, namely the assumptions of predictability and no signaling in time (NSIT). These assumptions involve only measurement statistics and hence are directly testable in experiments. This derivation of LGI, therefore, allows one to conclude that in a situation where NSIT is satisfied, the violation of LGI will imply that the underlying model is not predictable. As a novel implication of this derivation, we find application of LGI in randomness certification. It turns out that randomness can be certified from temporal correlations, even without knowing the details of the experimental devices, provided the observed correlations violate LGI but satisfy NSIT.

S. Mal, M. Banik and Sujit K. Choudhary

3.6. EXPERIMENTAL CONDENSED MATTER PHYSICS

1. **Photo- absorption properties of Ion Beam Irradiated TiO_2 (110) surfaces**

Rutile TiO_2(110) surfaces have been ion irradiated with low energy ion beams which lead to the formation of crystalline nanostructures on the surface as a result of competing processes of curvature dependent erosion and diffusion related smoothening. Interestingly, the nanostructures are anisotropic in size demonstrating a constrained size in $(1\bar{1}0)$. The results demonstrate dependence of photo-absorbance, at high fluence, on the length of the nanostructures in the fast diffusion direction. Raman Spectroscopy is being utilized to understand the lattice modifications after irradiation.

S. Varma, V. Solanki, I. Mishra, Shalik R. Joshi, N.C. Misra (Utkal Univ.), D. Kanjilal

2. **Kinetic Monte Carlo (KMC) Simulations and Comparison with ion irradiated Metallic Surfaces**

Ion irradiation of metallic surfaces demonstrate formation of intriguing nanodimensional patterns depending on several parameters viz. energy, flux, fluence and incident angle of ions. Our experiments have shown ripple like nanostructures on Ta surfaces. We are simulating the pattern formation using the KMC techniques, in (1+1) dimension, to understand the diffusion and erosion dynamics on ion irradiated surfaces. Scaling properties of the non-equilibriumsurfaces, thus generated, are also being investigated.

S. Varma, Shalik R. Joshi, T. Bagarati(HRI)

3. **Photo- absorption properties in UV-Vis range for ZnO nanostructures created via Atom Beam Sputtering**

ZnO nanostructures demonstrate many exciting applications in photo- voltaics as well as in gas sensing. We have utilized Atom Beam Sputtering technique to pattern the ZnO(0001) surfaces. The nanostructures thus fabricated display development of new phases as well as presence of oxygen vacancies. Moreover, with increased incidence angle of the atomic beam, a reduction in the nanostructure size is observed. The results demonstrate an enhancement of Photoabsorption for large nanostructures which display high oxygen vacancy content and several new crystalline phases. Modifications to ZnO lattice, after sputtering, are being explored by Raman Spectroscopy.

S. Varma, Vanaraj Solanki, Indrani Mishra, Shalik R. Joshi, D.K. Avasthi

4. **Interaction of Semiconductor Nanostructures with DNA**

Oxide semiconductor nanostructures display many interesting applications in variety of areas including drug delivery, nano- electronics etc. We are investigating the interaction of DNA with several oxide nanostructures, like TiO_2, ZnO etc., to understand the basic adsorption mechanisms of bio- molecule on nanostructures. The nanostructures have been fabricated by sputtering technique. The oxygen vacancies thus created are essential for the conjugation of DNA with the nanostructures. Strong interactions with specific vacancy sites have been demonstrated. These can have applications in implant technology and nano-bio- electronics.

S. Varma, Indrani Mishra, Subrata Majumder, U. Subudhi (IMMT)

5. **Magnetic Studies of Oxide nanostructures created by Ion sputtering**

Nanostructures have been fabricated on rutile TiO_2(110) single crystal surfaces using Ar ion beam sputtering technique. Pronounced quantum confinement effects in TiO2 nanodots lead to reduction in optical reflectance and bandgap widening. Moreover, a direct correlation between the size of nanostructures and their magnetic behavior has been observed. A switch to superparamagnetic behavior has also been observed for smaller nanostructures.

S. Varma, V. Solanki,I. Mishra, Shalik R. Joshi, N.C. Misra (Utkal Univ.), D. Kanjilal

6. **Resistive Switching characteristics of oxide nanoflakes**

Variation in resistive switching phenomena in oxide nanoflakes devices, fabricated with a simple hydrothermal growth process, has been investigated. The nanostructures display a defect concentration dependent bandgap. A comprehensive investigation of the transport properties has been carried out which utilizes the techniques of Conducting Atomic Force Microscope and Core-level Spectroscopy. The results show that the defect concentration can be utilized for modifying the switching behaviour of these nanostructures.

S. Varma and Vanaraj Solanki

7. **Electronic Structure of Iron Superconductors**

Our valence band photoelectron spectroscopic studies show a temperature dependent spectral weight transfer near the Fermi level in the Fe-based superconductor $FeSe_{1x}Te_x$. Using theoretical band structure calculations we haveshown that the weight transfer is due to the temperature induced changesin the $Fe(Se,Te)^4$ tetrahedra. These structural changes lead to shifts in theelectron occupancy from the xz/yz and x^2y^2 orbitals to the $3z^2r^2$ orbitals indicating a temperature induced crossover from a metallic state to an Orbital Selective Mott (OSM) Phase. Our study presents an observation of a temperature induced crossover to a low temperature OSM phase in the family of Fe chalcogenides.

Further, Inverse photoemission (IPES) spectroscopic measurements along with LDA based band structure calculations have been used to investigate the unoccupied electronic structure of the $FeSe_{1x}Te_x$ system. The observed doping and temperature dependent pseudogap in this system is found to be linked to the change in the chalcogen height in their geometric structure. The depletion in spectral weight from the near E_F states at low temperature in IPES has been correlated with results of the photoemission spectroscopy (PES). The coulomb correlation energy U, estimated from the combined PES and IPES spectra, signifies the enhancement in electron correlations in $FeSe_{1x}Te_x$, with doping. The formation of pseudogap in PES and IPES confirms the importance of correlations in the 11 family of Fe superconductors.

B. R. Sekhar and Collaborators

8. ARPES on GeSe

The valence band electronic structure of GeSe single crystals has been investigated using angle resolved photoemission spectroscopy (ARPES) and x-ray photoelectron spectroscopy. The experimentally observed bands from ARPES, match qualitatively with our LDA-based band structure calculations along the Z, Y and T symmetry directions. The valence band maximum occurs nearly midway along the Z direction, at a binding energy of 0.5 eV, substantiating the indirect band gap of GeSe. Non-dispersive features associated with surface states and indirect transitions have been observed. The difference in hybridization of Se and Ge 4p orbitals leads to the variation of dispersion along the three symmetry directions. The predominance of the *Se 4p z* orbitals, evidenced from theoretical calculations, may be the cause for highly dispersive bands along the T direction. Detailed electronic structure analysis reveals the significance of the cationanion *4p* orbitals hybridization in the valence band dispersion of IVVI semiconductors. This is the first comprehensive report of the electronic structure of a GeSe single crystal using ARPES in conjugation with theoretical band structure analysis.

B. R. Sekhar and Collaborators

9. Valence Band Photoemission on SrFBiS2 Superconductors

We have undertaken a comprehensive report on Rare Earth (La, Ce) doped $SrFBiS_2$ superconductors using valence band photoemission in conjugation with the LDA based band structure calculations. The changes in the electronic structure of $SrFBiS_2$ compound with rare earth (RE) doping have been focussed. RE doping introduces electron carriers causing an enhanced metallicity. The RE doped compounds exhibit a shift in the Fermi level towards the conduction band. Further, the degeneracy of bands along X-M direction at VBM and CBM is lifted due to RE doping. The reduced distortion of BiS plane and change in Fermi surface topology, is reflected as increased spectral weight near fermi level and a corresponding decrease in density of states at higher binding energy, for the RE doped compounds.

B. R. Sekhar and Collaborators

10. Electronic Stucture of Nd[$O_{1x}F_x$] FeAs

We have investiagted the valence band electronic structure of Nd[$O_{1x}F_x$]FeAs systems using photoemission spectroscopy. The reduced spectral weight near E_F for the Fluorine doped compound in comparison to the parent compound has been correlated with the reduced pnictogen height with doping. Further, a temperature dependent pseudogap formation has been observed in both the parent and doped compound. The temperature dependent pseudogap in the parent compound is attributed to the spin density wave existing at low temperature. On the other hand, the pseudogap formation in the doped compound is linked with the enhanced Fe-3d interorbital hybridisation, induced by the reduced pnictogen height at low temperature. This could lead to Orbital Selective Mottness of Fe-3d x^2-y^2 and yz/zx orbitals at low temperature. The observed spectral weight depletion and consequent pseudogap, for doped compounds exhibit a striking resemblance to that found in the (11) family of superconductor, demonstrating the role of multiorbital correlations in the family of Fe superconductors. The different origin of pseudogap formation in the parent (linked to SDW) and doped compound (linked to pnictogen height), signifies the intricate interplay of magnetsim and multiorbital correlations in the (1111) family of Fe superconductors.

B. R. Sekhar and Collaborators

11. Silver endotaxy in silicon under various ambient conditions and their use as surface enhanced Raman spectroscopy substrates

Search for reliable, robust and efficient substrates for surface enhanced Raman spectroscopy (SERS) leads to the growth of various shapes and nanostructures of noble metals, and in particular, Ag nanostructures for this purpose. Coherently embedded (also known as endotaxial) Ag nanostructures in silicon substrates can be made robust and reusable SERS substrates. In this paper, we showthe possibility of the growth of Ag endotaxial structures in Si crystal during Ar and low-vacuum annealing conditions while this is absent in O2 and ultra high vacuum (UHV) annealing conditions and along with their respective use as SERS substrates. Systems annealed under air-annealing and low-vacuum conditions were found to show larger enhancement factors (typicallyH” 5×10^5 in SERS measurement for 0.5 nMCrystal Violet (CV) molecule) while the systems prepared under UHV-annealing conditions (where no endotaxial Ag structures were formed) were found to be not effective as SERS substrates. Extensive electron microscopy, synchrotron X-ray diffraction and Rutherford backscattering spectrometry techniques were used to understand the structural aspects.

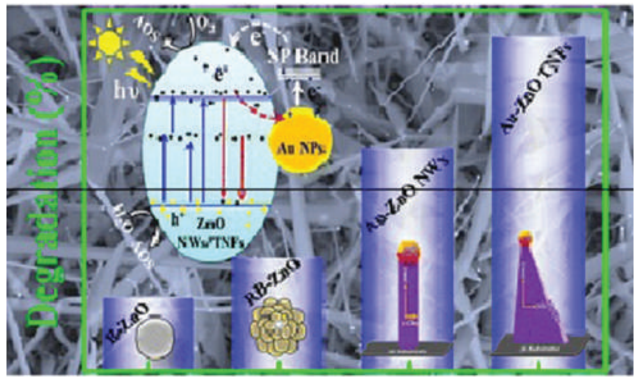
R. R. Juluri, A. Ghosh, A. Bhukta, R. Sathyavathi and P. V. Satyam,

12. Morphological variations in Au_xSi_y nanostructures under variable pressure and annealing conditions

Well-ordered, substrate symmetry-driven, AuxSiy structures of average size ~25 nm were formed under ultra-high vacuum (UHV) conditions using molecular beam epitaxy method. Post-annealing was done at 500 °C in three different vacuum conditions: (1) low vacuum (LV) (10"2 mbar), (2) high vacuum (HV) (10"5 mbar) and (3) UHV (10"10 mbar) (MBE chamber). For both HV and LV cases, the AuxSiy nanostructures were found to have their corners rounded unlike in UHV case where the structures have sharp edges. In all the above three cases, samples were exposed to air before annealing. In situ annealing inside UHV chamber without exposing to air resulted in well-aligned rectangles with sharp corners, while sharp but irregular island structures were found for air exposed and UHV annealing system. The role of residual gases present in LV and HV annealing environment and inhibition of lateral surface diffusion due to the presence of surface oxide (through air exposure) would be discussed. Annealing at various conditions yielded variation in the coverage and correspondingly, the average area of nanostructures varied from a ~329 nm2 (as deposited) to ~2,578 nm2 (at high temperature). High-resolution transmission electron microscopy (planar and cross section) has been utilized to study the morphological variations.

A. Rath, J. K. Dash, R. R. Juluri and P. V. Satyam,

13. Simple Growth of Faceted Au–ZnO Hetero-nanostructures on Silicon Substrates (Nanowires and Triangular Nanoflakes): A Shape and Defect Driven Enhanced Photocatalytic Performance under Visible Light



A simple single-step chemical vapor deposition (CVD) method has been used to grow the aceted Au–ZnO hetero-nanostructures (HNs) either with nanowires (NWs) or with triangular nanoflakes (TNFs) on crystalline silicon wafers with varying oxygen defect density in ZnO nanostructures. This work reports on the use of these nanostructures on substrates for photodegradation of rhodamine B (RhB) dyes and phenol under the visible light illumination. The photoluminescence measurements showed a substantial enhancement in the ratio of defect emission to band-edge emission for TNF (ratio H" 7) compared to NW structures (ratio d" 0.4), attributed to the presence of more oxygen defects in TNF sample. The TNF structures showed 1 order of magnitude enhancement in photocurrent density and an order of magnitude less charge-transfer resistance (Rct) compared to NWs resulting high-performance photocatalytic activity. The TNFs show enhanced photocatalytic performance compared to NWs. The observed rate constant for RhB degradation with TNF samples is 0.0305 min–1, which is

H"5.3 times higher compared to NWs case with 0.0058 min–1. A comparison has been made with bulk ZnO powders and ZnO nanostructures without Au to deduce the effect of plasmonic nanoparticles (Au) and the shape of ZnO in photocatalytic performance. The results reveal the enhanced photocatalytic capability for the triangular nanoflakes of ZnO toward RhB degradation with good reusability that can be attracted for practical applications.

A. Ghosh, P. Guha, A. K. Samantara, B. K. Jena, R. Bar, S. Ray and P. V. Satyam

15 Study of faceted Au nanoparticle capped ZnO nanowires : antireflection, surface enhanced Raman spectroscopy and photoluminescence aspects

A. Bimetallic thin film on semiconductor substrate has a lot of advantages compared to monometallic thin film. We have prepared bimetallic thin film (Au-Ag) on clean Si(5 5 12) using successive depositions of Ag and Au thin films. The growth of the thin films on reconstructed (2x1), Si(5 5 12) substrate has been studied using in situ RHEED. All the samples have been characterized using ex situ RBS and SEM. We have also carried out some experiments to observe the SERS efficiency of the (Au-Ag)/Si samples, for CV molecules.

A. Ghosh, R R Juluri, P Guha, R Sathyavathi, Ajit Dash, B K Jena and P V Satyam

16. Ag induced Au-Ag nanstructures under MBE conditions on high index silicon substrates

Due to dipping as Si substrate in (5%-10%) HF soln. in air, the native silicon oxide layer on Si substrate can be selectively etched out. Si dangling bonds are terminated by the hydrogen atoms. These substrates are inert against re-oxidation for a limited time in air. We have carried out some experiments to prepare Ag thin film on this etched Si(5 5 12) substrate, in MBE process. In situ RHEED has been done to find out the experimental conditions for the epitaxial growth. Further the samples have been micro graphed in ex situ SEM. Morphology dependence on the annealing condition and thickness of the thin film has been studied. 1-D Au nanostructures are extensively used for biomedical, catalyst and plasmonic applications. Au nanostructures with high aspect ratio on reconstructed Si substrate are also desired for studying metal semiconductor interconnects. Metal adatoms on reconstructed high index Si surfaces shows anisotropic surface diffusion. It makes high index Si surfaces an efficient template for growth of 1D metal nanostructures. Among different high index planes of Si, Si(5 5 12) forms stable, single domain reconstructed surface. We have studied that, sub monolayer Ag deposition prior to Au deposition on Si(5 5 12) surface remarkably modifies the morphology of Au thin film. Dependence of the morphology on metal (Au, Ag) thin film thicknesses and substrate annealing conditions is studied. Growth of thin film has been characterized using Scanning Electron Microscopy (SEM, High Resolution Transmission Electron Microscopy (HRTEM), Scanning Transmission Electron Microscopy (STEM), Rutherford Backscattering Spectroscopy (RBS Random/ Channeling) and Synchrotron X Ray Diffraction (XRD) and X Ray Reflectivity

(XRR) techniques. For (Au-Ag)/Si system, we have understood growth, morphology dependence on different annealing conditions. Efficiency for SERS application is also observed. A detailed analysis for the understanding the compositions have to be carried out.

Growth and morphology variation of Ag/H:Si(5 5 12) system with substrate temperature and film thickness has been observed. Further characterizations for studying the metal semiconductor interface and optical properties have to be done. Morphological evolution of the Au/Ag:Si(5 5 12) system, with substrate temperature, Ag thickness and Au thickness have been studied. Further in-situ studies (STM,STS, RHEED), STEM and RBS (Random/Channeling) have to done to understand growth mechanism.

A. Bhukta, P. Maiti, P. Guha, A. Ghosh and P. V. Satyam

Superconductivity:

17. Ir-reversibilityyyy and vortex lattice melting temperatures in $YBa_2Cu_3O_7$

The dc I-V characteristic of poly-crystalline $YBa_2Cu_3O_{7-X}$ high temperature superconductors (HTSC) is measured near the transition temperature (T_C). A difference in voltage was found for forward and reverse current directions near T_C. The measured dc voltage showed increased noise near T_c which is related to flicker 1/f noise. The experimental results are explained in terms of melting of the vortex lattice and irreversibility temperature which is observed near the superconducting transition in $YBa_2Cu_3O_{7-X}$. We also conclude that the plastic flow increases near the vortex lattice melting temperature.

S B Ota and Smita Ota, Mod.Phys.Lett.B

18. I. Energetic Ion Based Materials Science

Ion beam induced surface nanopatterning of semiconductors and their applications

18.a. Ion-beam fabrication of self-organized nanostructures

We are working on ion-beam fabrication of self-organized nanostructures on the surface of various materials with the following aims: (i) to explore pattern formation on different materials at low and medium energies (250 eV-2 keV and 50-100 keV, respectively), (ii) to explore the possibility of explaining pattern formation on a material in both energy regimes under the same framework, (iii) to explore the possibility of formulating a generalized picture of pattern formation on any material, and (iv) to use patterned substrates for nanoscale functionalization.

To start with, we exposed semiconductor surfaces to low and medium energy inert gas ions and tried to understand the underlying physics behind nanoscale pattern formation in terms of various experimental parameters. With the help of extensive numerical estimations, based on existing theories in conjunction with simulations, we have shown that synergetic roles of both ion-beam-induced curvature-dependent sputter erosion and prompt atomic redistribution are responsible for morphological evolution (formation or absence of patterns) on Si and Ge surfaces at medium ion energies. Although we have elucidated ripple formation on Si at low ion energies in the framework of solid flow model under ion bombardment; in a more recent work, ripple formation on Si at both energy regimes has been explained by considering synergetic roles of sputter erosion as well as ion-beam induced prompt atomic redistribution. For both Si and Ge, we have constructed parametric phase diagrams, showing ripple formation on both Si and Ge starts above a threshold incidence angle below which no patterns are formed. We have also shown that at higher incidence angles, ripple wave vector undergoes a transition from parallel to perpendicular to the ion-beam projection onto the sample surface before patterns disappear at even grazing incidence angles.

Ripples are also observed to undergo a transition to facets (in both low and medium energy regimes) for Si, Ge, and SiO-$_2$ over a small angular window due to ion-beam induced shadowing. Further, under concurrent substrate rotation, one creates mounds/dots on surface instead of ripples which are otherwise set to form if no rotation is present. Different types of patterned surfaces are useful for many applications, viz. solar cells, spintronics, optoelectronics, plasmonics, etc. where one can make use of them as templates for deposition of thin films or use as anti-reflecting and self-cleaning substrates.

T. Som, S.K. Garg, T. Basu, M. Kumar, D.P. Datta, D. Kanjilal

18.b. Applications of self-organized (patterned) nanostructured surfaces Tailoring photoluminescence of anti-reflective silicon nanofacets

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 capable of exhibiting room temperature ultraviolet (UV) photoluminescence (PL) which is attributed to inter-band transitions of the localized excitonic states of different Si-O bonds at the Si/SiOx interface. Time resolved photoluminescence measurements further confirm defect-induced radiative emission from the surface of silicon nanofacets. The PL intensity can be tuned by changing the aspect ratio of the facets by varying ion fluence for a given ion incidence angle.

T. Basu, M. Kumar, A. Kanjilal, and T. Som

19. Tunable field emission from silicon nanofacets

A fluence-dependent field emission study of ion-beam fabricated Si nanofacets have been carried out. Results based on bulk current-voltage spectroscopic measurements show an increase in the turn-on field as a function of ion fluence. This claim is further substantiated by performing local probe electrical transport measurements using atomic force microscopy-based dual pass tunneling current microscopy (DPTCM), conductive atomic force microscopy (cAFM), and Kelvin probe force microscopy techniques (KPFM). The present observations are attributed to the variation in the coverage of native oxide layer on the facets due to a variation in the dimension of facet apexes formed at different fluences.

T. Basu, M. Kumar, J. Ghatak, B. Satpati, and T. Som

20. Tunable anti-reflection from conformally grown Al-doped ZnO on faceted-Si

We have shown the efficacy of Al-doped ZnO (AZO) overlayer on ion-beam synthesized nanofaceted silicon for suppressing reflection loss. In particular, we have demonstrated thickness dependent tunable anti-reflection (AR) from conformally grown AZO layer, showing a systematic shift in the reflection minima from ultraviolet to visible to near-infrared ranges with increasing thickness. Tunable AR property is understood in light of depth dependent refractive index of nanofaceted silicon and AZO overlayer. This improved AR property significantly increases the fill-factor of such textured heterostructures compared to the ones based on planar silicon.

T. Basu, M. Kumar, A. Kanjilal, and T. Som

21. Tunable photoluminescence from conformally grown ZnO:Al thin films on rippled-Si

Low energy ion-beam fabricated Si ripples were used to grow AZO thin films having thicknesses in the range of 5 to 30 nm. For comparison, simultaneously AZO films were grown on pristine-Si substrates. It is observed that morphology of self-organized AZO films is driven by that of the underlying substrate. For instance, granular morphologies evolve for films deposited on pristine-Si substrates, whereas morphologies having chain-like arrangement (conformal to the rippled-Si substrates) are observed for AZO deposited on rippled-Si substrates. Fluorescence studies reveal that excitonic peaks corresponding to 5-15 nm thick AZO films, grown on rippled-Si substrates, show blue shift up to 7 nm while there is hardly any blue shift for 20 nm thick film (compared to their pristine counterparts). The observed blue shifts are attributed to quantum confinement effect, arising due to grain sizes and spatial arrangements driven by the morphology of underlying rippled-Si templates.

T. Basu, M. Kumar, C.P. Saini, A. Kanjilal, and T. Som

22. Magnetic anisotropy in Co thin films on rippled substrate

In-plane magnetic anisotropy in Co thin films, of varying thicknesses, grown on rippled-Ge substrates are investigated. Rippled-Ge substrates were synthesized with the help of couple of tens of keV Au-ions at room temperature and at oblique incidence angles. The substrates were well characterized using atomic force microscopy, scanning electron microscopy, and tunneling electron microscopy. Subsequently, thin films were deposited at various glancing angles with respect to the substrate normal by rf magnetron sputtering technique. The results are compared with the films deposited on polished Ge substrates as well. Co film grows conformally on rippled substrates up to a certain thickness where a strong magnetic anisotropy is observed.

S.A. Mollick, R. Singh, M. Saini, B. Satpati, D. Ghose, and T. Som,

23. Ion implantation induced modification of semiconductors

23.a. Evolution of microstructure

We are investigating the microstructure, composition, and optical properties of 60 keV Ar-ion implanted GaSb and InSb. Normally and obliquely incident Ar-ions lead to the formation of porous layers, in both GaSb and InSb, which contain nanofibers (diameter ~15-25 nm). While the nanostructured surfaces are found to be highly oxidized, the presence of nanocrystallites within amorphous nanostructures is detected even at the highest fluence of 3×10^{18} ions cm^{-2}. The nanoporous layer exhibits luminescence in the visible and the infrared wavelength regime due to oxide formation and retained crystallinity. In our model, we interpret structural evolution in terms of vacancy agglomeration and void growth during implantation.

On the other hand, MeV Sb-ion implantation into single-crystalline InSb gives rise to formation of a cellular structure which transforms to porous structure at higher ion fluences. Beyond a particular fluence, the structure transforms into a network of interconnecting nanorods of diameter ~20 nm. This is understood in the framework of ion-induced growth of nanocavities in InSb which interconnects with growing amount of damage due to MeV ion implantation.

D.P. Datta, S.K. Garg, A. Kanjilal, P.K. Sahoo, B. Satpati, S. Dhara, T.D. Das, P. Das, D. Kanjilal, and T. Som

23.b. Amorphization and beyond

Our present study involves a systematic study of MeV ion implantation-induced structural damage evolution in Ge as a function of ion fluence. Ge samples were irradiated at room temperature by MeV Au and Ge ions in the fluence range of 1×10^{12} to 5×10^{16} ions cm^{-2}. The amorphization threshold was determined by Rutherford backscattering spectrometry-channeling (RBS/C) spectrometry. The results were further supported by micro-Raman spectroscopy, high-resolution x-ray diffraction (XRD), and transmission electron microscopy (TEM) studies. Ion induced swelling of Ge is studied by surface profilometry as well as TEM and is explained in light of ion-matter interaction.

D.P. Datta and T. Som

24. Growth and characterization of oxide thin films useful for photovoltaics and other applications

Growth of oxide thin films by rf and pulsed dc magnetron sputtering

Copper oxide is a very useful material and offers a great potential for solar cells (as an absorbing layer) because of its abundance and cost effectiveness. In addition, it has a high absorption coefficient in the visible region, non-toxicity, and good charge transport properties. We have grown copper oxide films by rf magnetron sputtering technique. Growth-dependent physical properties and microstructure have a high significance for its suitable applications.

We have also studied the growth of ordered arrays of amorphous TiO_2 nano-columns by using rf magnetron sputtering. The nano-columnar films show high resistance and are found to be porous in nature which results from glancing angle sputter deposition. In fact, porosity has a linear relationship with increasing deposition angle. Optical reflectance of these films were also studied as a function of porosity. In addition, contact angle measurements show roughness-dependent transition from a hydrophilic to a hydrophobic surface.

M. Kumar, T. Basu, S. Chatterjee, and T. Som

Electrical transport properties of Copper Oxide thin films

The main working (absorbing) layer for oxide-based solar cells is copper oxide (Cu-O). Thus, to optimize the properties of Cu-O thin films, we have deposited the same on glass and silicon substrates in a simultaneous fashion by using rf magnetron sputtering technique. Our studies show that defect concentration can be controlled by tuning the deposition parameters. Interestingly, films grown under normally incident flux consist of higher oxygen vacancies. These ilms exhibit resistive switching behavior suitable for resistive random access memory (RRAM). On the other hand, films grown at 50° incident flux angle are of superior crystalline quality and consist of less number of oxygen vacancies but does not exhibit any resistive switching.

M. Kumr and T. Som

Field emission from nanostructured Copper Oxide thin films

Recently, we have reported a strong and sustained electron emission at low applied electric fileds from cuprous oxide nanostructured thin films on Si. In this work, using density functional theory approach, we have shown that the formation of oxygen vacancy plays a lead role in Fermi-level pinning energy along with the formation of impurity energy states within the bulk band gap, causing an enhancement of electron emission at low fields. The role of oxygen vacancies is further confirmed by the local surface potential mapping using Kelvin probe force microscope (KPFM) with simultaneous measurement of surface topography. We have also observed that in addition to oxygen vacancy, field emission also depends on surface morphology. This is also confirmed by simulation studies based on finite element method.

M. Kumar, S. Nandy, S. Chatterjee, R. Thapa, E. Fortunato, and T. Som

25. Developmental Activities

Development of Major Research Facilities:

In order to carry out research programmes in surface and interface physics we are developing some major research facilities:

Integrated UHV system for understanding low energy ion-beam-induced pattern evolution on surfaces and in-situ growth and characterization of nanofunctional thin films

Recently, we have custom designed an ion sputtering based nanofabrication unit coupled with MBE growth system and several characterization techniques. The unit is under production (M/s, Prevac, Poland) and is expected to be delivered during July, 2015. This will be a unique system in the country when all the proposed *in-situ* characterization tools will get connected to the basic unit in a piece-wise manner. Using this unit, we should be able to fabricate low energy ion-beam-induced self-organized surface nanostructures on semiconductors, oxides, and metals. In addition, these patterned substrates can be transferred to the integrated UHV growth chamber for *in-situ* deposition and characterization of nanofunctional thin films grown on the same.

T. Som and Collaborators

Electron cyclotron resonance ion source-based low-to-medium energy ion beam facility

We are in the process of developing an electron cyclotron resonance ion source-based low-to-medium energy ion beam facility at IOP, Bhubaneswar. This facility will bridge the gap of ion-energy, -current and -species which are not available from the existing 3 MV Pelletron accelerator. The facility will deliver highly charged ion beams for nanoscale manipulation of surfaces. In addition, one can make use of this facility to address a gamut of scientific problems like high current ion implantation, ion beam induced interface mixing, nanoscale pattern formation at surfaces, synthesis of embedded nanostructures, diffusion studies, ion beam induced epitaxial crystallization, dynamic annealing, and thin film/nanoscale magnetism. At present we have procured the ion sources and the magnet whereas the high voltage deck (on which the entire ion source will be housed) has been ordered. As a next step, we are going to develop the user beam lines and the experimental endstation(s). This will be a fully user facility open to the entire Indian scientific community working in this direction.

T. Som and Collaborators

26. Quantum confinement effects in low dimensional systems

The confinement effects of electrons in ultra thin films and nanowires grown on metallic and semiconducting substrates investigated through band mapping of their electronic structures through Angle resolved photoemission spectroscopy has been studied. It has been shown that finite electron reflectivity at the interface is sufficient to sustain the formation of quantum well states and weak quantum well resonance states even in closely matched metals. The expected parabolic dispersion of *sp* derived quantum well states for free standing layers undergoes deviations from parabolic behavior and undergoes modifications due to the underlying substrate bands, suggesting the effects of strong hybridization between the quantum well states and the substrate bands. Electron confinement effects in low dimensions as observed from the dispersion-less features in the band structures is also been investigated.

D. Topwal

27. Photoemission studies of the near E_F spectral weight shifts in $FeSe_{1-x}Te_x$ superconductor.

Our valence band photoelectron spectroscopic studies show a temperature dependent spectral weight transfer near the Fermi level in the Fe-based superconductor $FeSe_{1"x} Te_x$. Using theoretical band structure calculations we have shown that the weight transfer is due to the temperature induced changes in the $Fe(Se,Te)_4$ tetrahedra. These structural changes lead to shifts in the electron occupancy from the xz/yz and x^2 “ y^2 orbitals to the $3z^2$ “ r^2 orbitals indicating a temperature induced crossover from a metallic state to an Orbital Selective Mott (OSM) Phase. Our study presents an observation of a temperature induced crossover to a low temperature OSM phase in the family of Fe chalcogenides.

Paramita Mishra and Collaborators

28. Electronic structure of Germanium Selenide investigated using Ultra-Violet Photo-electron spectroscopy.

The valence band electronic structure of GeSe single crystals has been investigated using Angle Resolved Photoemission spectroscopy (ARPES) and X-ray photoelectron spectroscopy. The experimentally observed bands from ARPES, match qualitatively with our LDA based band structure calculations along the Ã-Z, Ã-Y and Ã-T symmetry directions. The valence band maximum occurs nearly midway along Ã-Z direction, at a binding energy of -0.5 eV, substantiating the indirect band gap of GeSe. Non dispersive features associated with surface states and indirect transitions have been observed. The difference in hybridisation of Se and Ge 4p orbitals leads to the variation of dispersion along the three symmetry directions. The pre dominance of the Se $4p_z$ orbitals, evidenced from theoretical calculations, may be the cause for highly dispersive bands along Ã-T direction. The detailed electronic structure analysis reveal the significance of the cation-anion 4p orbitals hybridisation in the valence band dispersion of IV-VI semiconductors. This is the first comprehensive report of electronic structure of GeSe single crystal using ARPES in conjugation with theoretical band structure analysis.

Paramita Mishra and Collaborators

29. Electronic structure of the Unoccupied electron energy states in $FeSe_{1-x}Te_x$

Inverse photoemission (IPES) spectroscopic study in supplement with LDA based band structure calculations have been used to investigate the unoccupied electronic states in $FeSe_{1-x}Te_x$. The observed doping and temperature dependent pseudogap has been associated with the change in chalcogen height. The depletion in spectral weight around 0.8 eV at low temperature in IPES has been correlated with the enhancement of the $3z^2$-r^2 orbitals around 0.3 eV in photoemission spectroscopy (PES). The coulomb correlation energy U, estimated from the PES and IPES spectra, signifies the enhancement in electron correlations with increase in x in $FeSe_{1-x}Te_x$. The formation of pseudogap in PES and IPES confirms the importance of correlations in the 11 family of Fe superconductors.

Paramita Mishra and Collaborators

30. Comparative study of the influence of Coulomb interaction

We have carried out photoemssion and a comparative study of the influence of Coulomb interaction and Hundâ•™s coupling on the electronic structure of FeSe and FeTe. Our calculations are based on density functional theory (DFT) with local density approximation (LDA + U) framework employed in TB-LMTO ASA code. We found the correlation effects are orbital selective due to the strength of interorbital hybridization among the different Fe-3d orbitals mediated via the chalcogen (Se/ Te-p) orbitals and are different in both the compounds. The Coulomb interaction is screened significantly by Te-p bands in FeTe. Similarly the orbital selection is different in both the compounds because of the difference in the chalcogen height

Himanshu Lohani and Collaborators

31. Developmental work(s) carried out on Superconductors as an interesting class of materials

Superconductors as an interesting class of materials, have gained impetus in the last few decades both due to its fundamental physics and technological applications. Various types of unconventional superconductors have been discovered in the last decades like Fe-pnictides and chalcogenides. Latest advancement in this series is Nb2PdS5, which exhibits relatively large upper critical field(Hc2= 32 T) in comparison to its low critical temperature(Tc= 5.8 K) . The Hc2 value is around 3 times more than the Pauli paramagnetic field value of 1.84*Tc. To know the origin of such a high Hc2, we have calculated the electronic structure of Nb2PdS5 under Density functional frame work using GGA approximation. Our results show that near Ef states are predominantly Ta-d and S-p hybridized states. Bands crossing the Fermi level have contribution from different Ta-d orbitals. The size of hole and electron pocket at the Brillouin zone face depends on Pd vacancy. The Pd atoms are placed at two different sites Pd1 and Pd2. The Pd2 is weakly bound and responsible for Pd vacancy in the system. The different binding energy of Pd1 and Pd2 obtained from the calculation is supported by our valence band photoemisson results. Pd vacancy and multiband effect could be the origin of the observed High value of Hc2 in Nb2PdS5 superconductor. Photoemission Experiments on similar High Hc2 superconductors Ta2PdS6 and Ta2PdTe6 are currently going on.

Himanshu Lohani and Collaborators

32. Analytical understanding of neutrino oscillation probability in the presence of NSI

Attempts have been made to come up with better analytical expression of oscillation probability in the light of large θ_{13}. Recently, it has been argued that neutrino oscillation in matter is best understood by allowing the mixing parameters and mass differences to vary with Wolfenstein parameter a. It was shown using the Jacobi method that one can obtain compact expressions for the mixing parameters and mass differences which can be plugged in the vacuum oscillation probability formula. In this work, we have tried to extend the formalism to come up with better analytical expression to the oscillation probabilities in the presence of non-standard interaction which becomes important when neutrino travels large distance inside the earth.

Sanjib Kumar Agarwalla, Yee Kao, Debashis Saha, and Tatsu Takeuchi

33. On D1-D5 system and their CFT duals

Currently we are studying the D1-D5 system and various orbifolds of these geometries that are smooth solitonic fuzzball solutions [2]. We explore the corresponding CFT duals. The solutions have ergoregion instability. We study the rate of radiation coming out of these geometries and the conserved charges associated with the radiation field.

Bidisha Chaborty and Collaborator

34. Research work related to the proposed mini-DINO direct dark matter

I carried out research work related to the proposed mini-DINO direct dark matter search experiment. My work involved using the GEANT4 framework to carry out simulations to ascertain the requirements for the shielding of background neutrons for that experiment.

Atanu Maulick and Collaborators

35. Equal Time Two-point Correlator using ADS/CFT

We study the equal time two point correlator for a strongly coupled field theory using ADS/CFT whose gravity dual are ADS Kasner and ADS-Kasner Soliton. For positive Kasner exponent we explicitly show that correlator does not develop any pole. Further,if we push the boundary surface towards initial singularity we observe that the two point function of the boundary theory gradually decreases to zero. We study this case for different values of positive kasner exponents and we observe that the qualitative behaviour of two point function remains similar.

Soumyabrata Chatterjee, S.Banerjee, S.Bhowmick and S.Mukherji

36. Work in Progress : different types of Vaidya like collapsing solutions and their properties

We are studying different types of Vaidya like collapsing solutions and their properties in higher dimension,and higher dimensional ADS background.The cases we are studying are charged null Vaidya solution,Einstein-Maxwell-Dilaton system , collapsing of a time like shell in ADS background etc.

Soumyabrata Chatterjee, S.Ganguli, A.Virmani

37. Non-enzymatic Optical Glucose Sensing Using ZnO Nanorods, Successful Demonstration with Human Serum

The highly sensitive, interference-free and non-enzymatic optical sensing of glucose has been made possible for the first time using the hydrothermally synthesized ZnO nanorods. The UV irradiation of glucose-treated ZnO nanorods decomposes glucose into hydrogen peroxide (H_2O_2) and gluconic acid by UV oxidation. The ZnO nanorods play the role of a catalyst like the oxidase used in the enzymatic glucose sensors. The photoluminescence (PL) intensity of the near-band edge emission of the ZnO nanorods linearly decreased with the increased concentration of H_2O_2. Therefore, the glucose concentration is monitored over a wide range, 0.5 – 30 mM, corresponding to 9 – 540 mg/dL. The concentration range of the linear region in the calibration curve is suitable for its clinical use as a glucose sensor, because the glucose concentration of human serum is typically in the range of 80 – 120 mg/dL. In addition, the optical glucose sensor made of the ZnO nanorods is free from interference by bovin serum albumin, ascorbic acid or uric acid, which is also present in human blood. The non-enzymatic ZnO-nanorod sensor has been demonstrated with human serum samples from both normal persons and diabetic patients. There is a good agreement between the glucose concentrations measured by the PL quenching and standard clinical methods.

Sachindra Nath Sarangi, Shinji Nozaki, and Surendra Nath Sahu

38. Selective Growth of ZnO Nano-Porous Films by the Hydrothermal Technique

Well crystallized ZnO nano-porous films were selectively grown on the Al substrate using zinc nitrate ($Zn(NO_3)_2$) and hexamethylenetetramine ($(CH_2)_6N_4$) by the hydrothermal growth technique. We already reported the high-quality ZnO nanorods vertically grown on a GaN substrate owing to a good lattice match. However, in case of Al substrate, it was not a nanorods but a nano-porous film consisting of three dimensional 3D nanoflakes. The as-grown nano-porous films were highly crystalline, possessed a wurtzite hexagonal, confirmed from the X-ray diffraction (XRD) measurement. The proton induced X-ray emission (PIXE) experiment confirms the absence of any foreign element in ppm level in ZnO nano-porous film. It is suggested that the nanorod grows laterally on Al film and merges with the adjacent nanorods to form 2D nanoflakes. As the growth continues, the 2D nanoflakes are piled up to form 3D nanoflakes and finally a nano-porous film as seen under Scanning Electron Microscope.

S.N. Sarangi, D. K. Ray and A. K. Behera

4

PUBLICATIONS

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98. **Medium energy Ar^+-ion induced ripple formation: Role of ion energy in pattern formation ;** S. K. Garg, D. P. Datta, J. Ghatak, S. R. Tripathy, D. Kanjilal, and T. Som Appl. Surf. Sci. 317 (2014) 476.

99. **Thickness-control-led photoresponsivity of ZnO: Al/Si heterostructures: Role of junction barrier height** ; Tanmoy Basu, Mohit Kumar, Tapobrata Som Mater. Lett. 188 (2014) 153.

100. **Semi-insulating behaviour of self-assembled tin(IV)corrole nanospheres ;** Woormileela Sinha, Mohit Kumar, Antara Garai, Chandra Shekhar Purohit, Tapobrata Som and Sanjib Kar, Dalton Trans. 43 (2014) 12564.

101. **Improved broadband antireflection in Schottky-like junction of conformal Al-doped ZnO layer on chemically textured Si surfaces;** C. P. Saini, Barman, M. Kumar, P. K. Sahoo, T. Som, and A. Kanjilal Appl. Phys. Lett. 105 (2014) 123901.

102. **Tailoring room temperature photoluminscence of antireflective silicon nanofacets;** Tanmoy Basu, M. Kumar, A. Kanjilal, J. Ghatak, P. K. Sahoo, and T. Som, J. Appl. Phys. 116 (2014) 114309.

103. **60 KeV Ar^+ -ion induced modification of microstructural, compositional, and vibrational properties of InSb;** D. P. Datta, S. K. Garg, B. Satpati, P. K. Sahoo, A. Kanjilal, S. Dhara, D. Kanjilal, and T. Som, J. Appl. Phys. 116 (2014) 143502.

104. **Grain Growth Stagnation in Gold Thin Films on Annealing in Vacuum;** P. Dash, H. Rath, B. N. Dash, T. Som, U. P. Singh, S. Ojha, D. Kanjilal, N. C. Mishra Adv. Sci. Lett. 20 (2014) 552.

105. **Resonance Raman spectroscopic study for radial vibrational modes in ultra-thin Walled TiO-2 nanotubes;** Rajini P. Antony, Arup Dasgupta, Sudipta Mahana, D. Topwal and S. Dhara. ; J. Raman Spectrosc., 46, 231 (2015)

106. **Quantum confinement effects in low dimensional systems**; D. Topwal ; Pramana- J. Phys. 84, 1023 (2015)

107. **Direct transformation of amorphous to preferentially oriented rutile phase in DC sputtered TiO_2 thin film:** H. Rath, P. Dash, **T. Som**, U.P. Singh, N. C. Mishra, Adv. Sci. Lett. 20 (2014) 638.

108. S**ynthesis, electron transport, and charge storage properties of fullerene–zinc porphyrin hybrid nanodiscs ;** Antara Garai, Mohit Kumar, Woormileela Sinha, Sriparna Chatterjee, Chandra Shekhar Purohit, T. Som, and Sanjib Kar, RSC Advances 109 (2014) 64119.

109. **Efficient Field Emission from Vertically Aligned $Cu_2O_{1-}\ddot{a}$(111) Nanostructure Influenced by Oxygen Vacancy ;** Suman Nandy, Ranjit Thapa, Mohit Kumar, T. Som, Nenad Bundaleski, Orlando M. N. D. Teodoro, Rodrigo Martins, and Elvira Fortunato, Adv. Funct. Mater. (2014); DOI: 10.1002/adfm.201402910.

110. **Chemical freeze-out parameters from Au+Au collisions at $\sqrt{S_{NN}} = 7.7$, 11.5 and 39 GeV. ;** Sabita Das (for the STAR Collaboration) Quark-Gluon-Plasma (2014) ISBN: 978-81-8487-407-5.0

111**. ZnO Nanorod-Based Non-Enzymatic Optical Glucose Biosensor** ; S. N. Sarangi, S. Nozaki, S. N. Sahu Journal of Biomedical Nanotechnology (2015) 11 (6), 988-996.

112**. Selective Growth of ZnONano-Porous Films by the Hydrothermal Technique** ; S. N Sarangi, DK Ray, AK Behera International Journal of ChemTech Research (2014) 7 (3), 1656-1660.

113. **Analysis of strain-induced crystallinity in neutron irradiated amorphous PET fiber ;** B. Mallick, *Appl. Phys.* A , DOI 10.1007/s00339-015-9009-3.

114. **Effect of MeV electron beam irradiation on fracture healing of tibia bone of rabbit** ; S. K. Sahoo, B. Mallick , I. Nath, R. N. Mukharjee, *Int J Biol Med Res.* 5(4), 4569-4577, 2014.

115. **Photoemission studies of the near E F spectral weight shifts in FeSe1-xTex superconductor;** P. Mishra, H. Lohani, R.A.Zargar, V.P.S. Awana, B.R. Sekhar, Journal of Physics Condensed Matter 26 (2014) 425501.

116. **Structural and optical study of MeV cobalt ion implanted silicon**; P. Mishra et al. , Advanced Materials Letters 5 (2014) 699 .

117. **Investigation of correlation effects in FeSe and FeTe by LDA+U method;** H. Lohani, P. Mishra, B.R. Sekhar, Physica C 512 (2015) 54.

118. **Defect controlled ferromagnetism in xenon ion irradiated zinc oxide;** P. Satyarthi, S. Ghosh, P. Mishra, B.R. Sekhar, F. singh, P. Kumar, D. Kanjilal, R.S. Dhaka, P. Srivastava, Journal of Magnetism and Magnetic Materials 385 (2015) 318

119**. Photoemission studies of the near EF spectral weight shifts in FeSe superconductor** ; P Mishra, H Lohani, R A Zargar, V P S Awana and B R Sekhar, JPCM, vol-26, page425501(2014)

120. **Investigation of Correlation Effects in FeSe and FeTe by LDA + U Method** ; H. Lohani, P. Mishra and B. R. Sekhar, Phyica-c vol-512, page 54-60(2015).

121. **Irreversibility and vortex lattice melting temperatures in $YBa_2Cu_3O_7$** ; S B Ota and Smita Ota, Mod.Phys.Lett.B (2014).

4.2. Papers Communicated in Refereed Journals :

1. **Current carried by evanescent modes and possible device application ;** Sreemoyee Mukherjee, P. Singha Deo, A. M. Jayannavar arXiv:1411.5284.

2. **Macrospin in external magnetic field: Entropy production and fluctuation-theorems** ; Swarnali Bandopadhyay, Debasish Chaudhuri, A. M. Jayannavar, arXiv:1412.6812

3. **Quarkonia Disintegration due to time dependence of the $q\bar{q}$ potentiall in Relativistic Heavy Ion Collisions** ; Partha Bagchi and Ajit M. Srivastava, submitted for publication to Phys.Rev.C, arXiv: 1411.5596

4. **Probing dynamics of phase transitions occurring inside a pulsar ;** P. Bagchi, A. Das, B. Layek, and A.M. Srivastava, arXiv: 1412.4279.

5. **Effects of Phase Transition induced density fluctuations on pulsar dynamics ;** P. Bagchi, A. Das, B. Layek and A. M. Srivastava, Submitted to Phys. Lett. B.

6. **More Communication with less entanglement ;** Pankaj Agrawal, S. Adhikari, and S. Nandi, arXiv preprint arXiv:1409.1810.

7. **Quantum Discord has local and nonlocal quantumness ;** Pankaj Agrawal, I. Chakrabarty, Sk Sazim, and Arun K Pati, arXiv preprint arXiv:1502.00857.

8. **Bell-Type inequalities can act as a measure of entanglement** ; Chandan Datta, Pankaj Agrawal, and Sujit K. Choudhary, arXiv preprint arXiv:1503.08495.

9. **New Power to Measure Supernova θe with Large Liquid Scintillator Detectors ;** Ranjan Laha, John F. Beacom, Sanjib Kumar Agarwalla, Submitted in Physical Review D (PRD), e-Print arXiv: 1412.8425 [hep-ph]

10. **Probing Non-Standard Interactions at Daya Bay** ; Sanjib Kumar Agarwalla, Partha Bagchi, David V. Forero, Mariam Tortola, Submitted in Journal of High Energy Physics (JHEP), e-Print arXiv: 1412.1064 [hep-ph]

11. **The LBNO long-baseline oscillation sensitivities with two conventional neutrino beams at different baselines ;** S.K. Agarwalla et al., Submitted in Journal of High Energy Physics (JHEP), e-Print arXiv: 1412.0804 [hep-ph]

12. **A note on AdS cosmology and gauge theory correlator;** Souvik Banerjee, Samrat Bhowmick, Soumyabrata Chatterjee, Sudipta Mukherji, submitted to JHEP.

13. **Optimised sensitivity to leptonic CP violation from spectral information: the LBNO case at 2300 km baseline ;** S.K. Agarwalla et al., Submitted in Journal of High Energy Physics (JHEP), e-Print arXiv: 1412.0593 [hep-ph]

14. **Proton decay and new contribution to neutrino-less double beta decay in SO(10) with low-mass Z-prime boson, observable n-nbar oscillation, lepton flavor violation, and rare kaon decay ;** M. K. Parida, R. L. Awasthi and P. K.Sahu, arXiv:1401.1412; JHEP 1501 (2015) 045.

15**. Temporal correlations and Device-Independent randomness ;** Authors: S. Mal, M. Banik and Sujit K. Choudhary, Reference: arXiv:1406.5754

16. **The structural and decay properties of francium isotopes** ; M. Bhuyan, S. Mahapatro, S. K. Singh and S. K. Patra, Int. J. Mod. Phys. E

17. **The effect of self interacting isoscalar-vector meson on finite nuclei and infinite nuclear matter**; S. K. Biswal, S. K. Singh, M. Bhuyan and S.K. Patra, Brazilian Journal of Physics .

18. **Softness of Sn isotopes in semi-classical approximation** ; S. K. Biswal, S. K. Singh, M. Bhuyan and S. K. Patra, Mod. Phys. Lett. A

19. **Effects of isovector scalar ä – meson on Ë – hypernuclei ;** M. Ikram, S. K.Singh, S. K. Biswal and S. K. Patra, Int. J. Mod. Phys. E

20. **Nuclear Structure study of some bubble nuclei in light mass region using mean field formalism** ; R. N. Panda, M. K. Sharma and S. K.Patra. Chinese Physics C.

21**. Nuclear structure aspects of double beta decay nuclei in self-consistent Hartree-Fock model;** S.K. Ghorui, P.K. Raina, P.K. Rath and C.R. Praharaj, (communicated).

22. **Exploration of nuclear matter and finite nuclei observables** ; S. K. Patra, S. K. Biswal, S. K. Singh and M. Bhuyan, (communicated).

23. **Energy and Centrality dependence of freeze-out parameters in search of the QCD critical point from the Beam Energy Scan program at RHIC;** L. Adamczyk, ..P. K. Sahu...., S. Das et al. , Target journal: Phys. Rev. Lett. STAR Collaboration.

24. **Bulk properties from the Beam Energy Scan program at RHIC**, L. Adamczyk, .P. K. Sahu.., S. Das et al., Phys. Rev. C. STAR Collaboration. (under GPC review)

25. **Electronic Stucture of Nd[$O_{1x}F_x$]FeAs investigated using Photoemission Spectroscopy** ; P. Mishra, H. Lohani, V.P.S. Awana and B. R. Sekhar Communicated to Supercon. Sci and Tech, (2015).

26. **Electronic structure of rare-earth doped $SrFBiS_2$ superconductors from Photoemission Spectroscopic studies**.; P. Mishra, H. Lohani, V.P.S. Awana and B. R. Sekhar Communicated to Physica C, (2015).

27. **Correlation between Hc_2 and valence band in Pd based ternary chalco-genides revealed by photoemission study** ; H. Lohani, P. Mishra and B. R. Sekhar ; (Under Communuication)

28. **CH3NH3PbI3 A potential solar cell candidate: Structural and Spectroscopic investigations;** Pranoy Nandi, Chandan Giri, Dinesh Topwal and U. Manju ; J. Electron Spectrosc. Relat. Phenom. (Under review, 2015).

29**. Structural and electronic phase evolution of Tin dioxide;** Sudipta Mahana, Pitamber Sapkota, Saptarshi Ghosh, U. Manju and D. Topwal ; J. Electron Spectrosc. Relat. Phenom. (Under review, 2015), Manuscript available on request.

30. **Cosmic ray test of Mini-drift Thick Gas Electron Multiplier for Transition Radiation Detector;** Shuai Yang, Sabita Das, Zhangbu Xu et al. arXiv:1412.4769, Accepted for publication in Nuclear Instruments and Methods A.

31. **Freeze out Parameters in Heavy-Ion Collisions at AGS, SPS, RHIC, and LHC Energies;** Sandeep Chatterjee, Sabita Das, Bedangadas Mohanty et al., Accepted for publication in Advances in High Energy Physics.

32. **Electronic structure of Germanium Selenide investigated using Ultra-Violet Photo-electron spectroscopy**; P. Mishra, H. Lohani, A.K. Kundu, R. Patel, G.K. Solanki, Krishnakumar S.R. Menon, B.R. Sekhar, Accepted in Semiconductor Science and Technology

33. **Ion beam induced Chemical and Morphological changes in TiO_2 films deposited on Si(111) Surface;** R. R. Mohanta, V. R. R. Medicherla, K. L. Mohanta, Nimai C Nayak, S. Majumder, Vanaraj Solanki, Shikha Varma, D M Phase, V Sathe, Appl. Surf. Sci.

34. **Enhancement of thermoelectric power of PbTe:Ag nanocomposite thin films** ; Manju Bala, S. Gupta, T. S. Tripathi, Shikha Varma, Surya K. Tripathi, K. Asokan and D. K. Avasthi, Royal Soc. Chem. Adv.

35. **A15 compounds, HTSC and strong coupling superconductors;** S B Ota, 2015 APS March meeting, USA

36. **Implications of lack-of-ergodicity in 2D Potts model ;** Smita Ota and S B Ota, 2015 APS March meeting, USA

37. **On General orbifolded JMaRT and CFT duals** ; Bidisha Chakrabarty, David Turton and Amitabh Virmani submitted.

38. **Band Structures and K Isomers in some Rare-earth nuclei;** S.K. Ghorui, Z. Naik, B.B. Sahu and C.R. Praharaj, (communicated).

39. **Structure of Rotational Bands and K Isomers in $^{168"176}$Hf Nuclei;** B.B. Sahu, Z.Naik, S.K. Ghorui and C.R. Praharaj, (communicated).

40. **Vortex lattice melting and irreversibility temperatures in $YBa_2Cu_3O_7$; S B Ota**, J.Phy.Ast. (2014) Submitted.

41. **Semiconductor diodes for measurement of low temperatures**; S B Ota and Smita Ota, J.Phy.Ast. (2014). Submitted

4.3. Conference Proceedings :

1. **Energy Spectra and electromagnetic transition rates of ^{160,162,164}Gd in the projected Hartree-Fock model** ; S.K Ghorui, C.R. Praharaj, P.K. Raina, Zashmir Naik, S.K. Patra; American Institute of Physics Conference Proceedings, Vol 1609, 135 (2014) .

2. **Band structure and Deformed Configurations in ^{166}Er** ; B.B. Sahu, S.K. Ghorui, C.R. Praharaj, S.K. Patra and Zashmir Naik, Proceedings of the DAE Symposium on Nuclear Physics 59 (2014) p.254 .

3. **Development of a triple GEM detector prototype;** Rajendra Nath Patra, Amit Nanda, Sharmili Rudra, S. Biswas, B. Mohanty, T. K. Nayak, P. K. Sahu, S. Sahu., 7th International Conference on Physics and Astrophysics of Quark Gluon Plasma (ICPAQGP 2015), 2-6 February, 2015, VECC, Kolkata, India.

4. **Radial modes of oscillations of slowly rotating magnetized compact stars: Journal of Physics ;** N. R. Panda, K. K. Mohanta and P. K. Sahu, Conference Series 599 (2015) 012036 (2015).

5. **Maximum masses and radial oscillation of hybrid stars in presence of strong magnetic fields ;** N. R. Panda, K. K. Mohanta and P. K. Sahu , Proceedings of the Indian National Science Academy, 81, No. 1 February Special Issue 2015 pp. 256-266 : : (2015).

6. **Fabrication of Resistive Plate Chamber using Bakelite;** Himangshu Neog, Sharmili Rudra, M. R. Bhuyan, S. Biswas, B. Mohanty, Rudra- narayan Mohanty, P. K. Sahu, and S. Sahu. Proceedings of the DAE Symposium on Nuclear Physics. Volume 59, (2014), 874-875.

7. **Development of Data logger for atmospheric pressure, temperature and relative humidity for gas-filled detector. ;** S. Sahu, M. R. Bhuyan, S. Biswas, B. Mohanty, and P. K. Sahu. Proceedings of the DAE Symposium on Nuclear Physics. Volume 59, (2014), 876-877.

8. **Chemical Freeze out condition for central Heavy-ion Collisions at AGS, SPS, RHIC and LHC Energies ;** Sandeep Chatterjee, Sabita Das, Bedangadas Mohanty et al., Proceedings of the DAE Symposium on Nuclear Physics (2014) 59.

9. **Identified particle production and freeze-out properties in heavy-ion collisions in RHIC BES program ;** Sabita Das , EPJ Web of Conf. 90 (2015) 08007. STAR Collaboration.

10. **Chemical freeze-out parameters in Beam Energy Scan program of STAR at RHIC;** Sabita Das , EPJ Web of Conf. 90 (2015) 10003. STAR Collaboration.

11. **Study of freeze-out dynamics in STAR at RHIC Beam Energy Scan Program ;** Sabita Das , J. Phys. Conf. Ser. 509 (2014) 012066. STAR Collaboration.

4.3. Books Edited :

1. **Engineering Practical Physics**

   S. Panigrahi and B. Mallick
   Publisher: Cengage Learning (2015)
   ISBN: 9788131525203

5 COLLOQUIA & SEMINARS

5.1 COLLOQUIA

1. **Prof. Subha Majumdar**, TIFR, Mumbai : Big Bang flexes its BICEPs Looking at the earliest Times of our Universe, 15.04.2014

2. **Prof. Varsha Banerjee**, Indian Institute of Tech., New Delhi : Fractal Signatures in Multi-Scale Domain Morphologies, 05.05.2014

3. **Dr. Borun Chowdhury** (Arizona State University) : The information paradox: Still alive and kicking, 28.05.2014

4. **Prof. Barsha Banerjee,** IIT, Delhi : Fractal Signature in Multi-Scale Domain Morphologies, 09.06.2014

5. **Prof. Tarun Souradeep Ghosh,** IUCAA, Pune : Cosmology with Cosmic Microwave Background Radiation: COBE to Planck, 23.07.2014

6. **Prof. Samir Mathur,** Ohio State University : The black hole information paradox, and its resolution in string theory, 25.07.2014

7. **Dr. Arun K. Pati ,** HRI, Allahabad : Measurement of Non-Hermitian Operators in Quantum Theory, 18.08.2014

8. **Prof. Subrata Tripathi**, Ex-Professor, TIFR, Mumbai : Membranes : Fundamentals and Applications, 03.1.2014

5.2 GENERAL SEMINARS

1. **Dr.Prabhat R.Pujahari**, Postdoctoral Research Fellow Dept. of Physics, Wayne State University : Two-particle differential correlations in p-Pb and Pb-Pb collisions in ALICE at the LHC, 03.04.2014

2. **Dr. Krishnacharya**, Department of Physics, IIT Kanpur : Limitless Beauty of Soft Matter: Surface and Interfacial Phenomenon (wetting, adhesion, friction and SLIPs), 19.05.2014

3. **Dr. Sandeep Chatterjee**, NISER, Bhubaneswar : Model Studies of the Warm and Dense Matter Produced in Heavy Ion Collisions, 20.05.2014

4. **Dr. P.S. Mohanty** (University of Lund, Sweden) : Soft colloids as a model system with an interaction tunable from long-range to soft and dipolar, 25.06.2014

5. **Prof. Ananda Hota** ,UM-DAE CBS, Mumbai and RAD@home, India : Any BSc/BE Can Do Research using GMRT via RAD@home (#RADathome #ABCDresearch), 26.06.2014

6. **Prof. Ramki Kalayanaraman,** University of Tennessee, Knoxville, USA : Bimetalic and Symbiotic Nanoparticles: Synthesis and new physical properties, 09.07.2014

7. **Dr. Atri Bhattacharya** (University of Arizona) : Probing the ultra-high energies with large Volume detectors, 06.08.2014

8. **Dr. Swapnil Patil**, Dresden, Germany : Photoemission insight into Exotic Low Temperature Physics of Rare Earth based Kondo systems, 13.08.2014

9. **Dr. V.K. Anand** , Helmholtz-Zentrum Berlin für Materialien und Energie, Berlin, Germany : Magnetism and Superconductivity in ACo_2As_2 and APd_2As_2 and Cluster-glass behavior in $CeRuSn_3$ and $PrRhSn_3$, 19.08.2014

10. **Dr. Surasree Mazumder** , VECC, Kolkata : Transport of heavy quarks in Quark Gluon1 Plasma, 25.08.2014

11. **Dr. Chirashree Lohiri**, Dept. of Physics,University of Calcutta : Astrophysical rp-process with nuclear structure inputs, 02.09.2014

12. **Dr. S.A. Mollick**, SINP, Kolkata : Ion Induced Pattern Formation on Semiconducting Surface, 08.09.2014

13. **Dr. S. K. Ghorui**, IIT Ropar : Double Beta Decay study of Tin : A Theoretical and Experimental Perspective, 15.09.2014

14. **Dr. Karon Singh Vinayak**, PDF, VECC, Kolkata : study of Density Dependant of Symmetr Energy and IQMD, 22.09.2014

15. **Dr. Satyabrata Mohapatra ,** School of Basic and Applied Sciences, Guru Gobind Singh Indraprastha University, New Delhi : Synthesis and ion beam engineering of hybrid nanostructures and plasmonic nanocomposites, 30.09.2014

16. **Dr. Tapash R. Rautray**, ITER University, Bhubaneswar : Synthesis and Characterization of Biomaterials using Ion beam and Electrochemical Techniques, 01.10.2014

17. **Dr. Haraprasanna Lenka**, Asst. Professor, Dept. of Physics International Institute of Information Technology (IIITB), Bhubaneswar : Materials modification and characterization by low energy ion accelerators, 08.10.2014

18. **Dr. Sandeep Kumar,** Central University of Rajastha, Ajmer : Highly Mn ion doped GaAs nanowires and their transport properties, 30.10.201

19. **Dr. Pavan Kumar Aluri**, IUCAA, Pune : Signals of statistical anisotropy in Cosmology, 05.1.2014

20. **Dr. Debi Prasad Datta**, PDF, IOP : Ion-beam induced synthesis and modification of nanostructures: Fundamentals and some applications, 08.10.2014

21. **Dr. Neeraj Shukla**,UGC-DAE CSR Kalpakkam Node, Tamil Nadu : Ion Beam Induced nano-structuring and magnetic ordering in Graphite, 27.10.2014

22. **Dr. Sudipto Muhuri** (University of Pune) : Jamming transition in a driven lattice gas, 11.1.2014

23. **Dr. N. Nirmal Thyagu** (MPI, Goettingen, Germany) : Electrical precursors in granular slip events, 11.11.2014

24. **Dr. A.K.Sarangi**, UCIL, Jaduguda : Nuclear Power, Nuclear Energy and Global Development, 12.12.2014

25. **Dr. Ajay Tripathy**, Dept. of Physics, Sikkim University : Ejection of magnetic field sensitive atoms from an optical, 22.12.2014

26. **Dr. Archana Tiwari** ,Dept. of Physics ,Sikkim University : Selective manipulation of an endohedral ion inside fullerene cages, 23.12.2014

27. **Dr. Satrajit Ghosh** , (APC Colege, Kolkata) : Design and working of reversible computers, 23.12.2014

28. **Tanmoy Basu**, IOP : Ion-beam induced nanostructuring of Si: Fundamentals and some applications, 30.12.2014

29. Prof. R.Palit, TIFR, Mumbai : Physics opportunity at NUSTAR-FAIR, 05.01.2015

30. Dr. Sovan Chakraborty (MPI, Munich) : Neutrino Astrophysics: Challenges and Possibilities, 14.01.2015

31. Prof. M.P.Das, Australian National University, Australia. : Are there fundamental theories in low energy physics?, 22.01.2015

32. Dr.S.Dhara, IGCAR, Kalpakkam : Spectroscopic Imaging in the Sub-diffraction Limit and Beyond, 28.01.2015

33. Dr. Arnab Chatterjee, SINP, Kolkata : Statistical physics of social systems, 29.01.2015

34. Dr. Debasish Chaudhuri (IIT Hyderabad) : Soft and active matter, 06.02.2015

35. Dr.Shamik Gupta (Universite Paris-Sud, France) ; Physics of long-range interacting systems, 10.02.2015

36. Dr. Ashish Kumar Mishra , Materials Sci. & Engg, Rensselaer Polytechnic Institute, USA : Carbon Based Nanomaterials : Synthesis, Energy & Environmental Aplications, 16.02.2015

37. Dr. Debakanta Samal, MPI Solid State Research, Stuttgart, Germany : Emergent electronic and magnetic phenomena in atomic-engineered oxide layers and heterostructures: An intriguing means to design high-Tc superconductor, 23.02.2015

38. Professor M. Sivakumar (School of Physics, University of Hyderabad) : Higher Spins Theories: Past, Present, and Future, 24.02.2015.

39. Dr. Arup Kumar Rath, Scientist, NCL, Pune, Nanotechnology for efficient and affordable solar power 27.02.2015

40. Dr. Bhola Nath Pal, Indian Institute of Technology, Varanasi : Optoelectronic applications of colloidal quantum dots (QDs), 04.03.2015

41. Mrutunjaya Bhuyan, Affiliation: Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing, China : Multidimensional Constrained Relativistic Mean Field Theory (MDC-RMF): Transitional Nuclei, 26.03.2015

5.2 SEMINARS (General Seminars Through Sky pe, Group General Seminars, Group Seminars etc.)

1. **Dr. Subhra Sen** , Gupta (RIKEN, Japan) : Novel Aspects of the Coulomb Interaction in Bulk and Nano-structured Correlated Electron Systems, 06.05.2014

2. **Prof. Anjan Ananda Sen**, Jamia Millia Islami University : Dark Energy After Planck, 07.05.2014

3. **Professor Vivek Datar ,** Head, Nuclear Physics Division, BARC, Mumbai : Melting of shell effects and radiating dumbbells – two interesting problems in nuclear physics, 15.05.2014

4. **Dr. Borun Chowdhury** (Arizona State University) : A hole-ographic spacetime, 30.05.2014

5. **Prof D.K. Goswami,** IIT, Kharagpur : Assembling Organic Molecules for Efficient Electronic Device Fabrication, 12.06.2014

6. **Dr. Nitali Dash,** INO, TIFR, Mumbai : Search for Exotic Particles using ICAL at INO, 13.06.2014

7. **Dr. Surajit Kumar Hazra.** Department of Physics & Materials Science ,JUIT, Waknaghat, Himachal Pradesh : Palladium nanoparticles: A material for selective hydrogen sensing, 16.06.2014

8. **Dr. Siba Prasad Das**, PDF, IOP : Signatures of the Higgs Boson using b-jet and tau-jet tragging, 26.06.2014

9. **Semanti Dutta** (RKM Vivekananda University) : Modeling DNA on a fractal lattice : A focus on its thermodynamic behavior, 04.07.2014

10. **Mahesh Chandrasekhar Gandikota** (NIER) : Martensitic phase transition in T4 bacteriophage tail sheath, 04.07.2014

11. **Prof. A.B. Santra**, BARC, Mumbai : Chiral Symmetry and Nuclear Matter Equation of State, 09.07.2014

12. **Professor Kalyan Kundu :** A theoretical study of formation of clusters in one and two dimensions using reaction-diffusion models, 17.07.2014

13. **Professor Ashok Das**, University of Rochester : Gauge Independence of the fermion mass: Part 2, 24.07.2014

14. **Prof. Samir Mathur** : Confusions about the information paradox, 24.07.2014

15. **Dr. Atri Bhattacharya** (University of Arizona) : Detecting TeV-PeV scale dark matter signatures at the IceCube neutrino detector, 04.08.2014

16. **Dr. Sayantani Lahiri,** Jadavpur University : Radion Dynamics In Warped Braneworld Scenario, 06.08.2014

17. **Satyabrata Adhikari :** Detection and Classification of Entanglement, 12.08.2014

18. **Dr. Rajesh Gupta** (ICTP) : Some Developments in Compulation of Quantum Entropy of Extremal Black Hole, 22.08.2014

19. **Dr. Anurag Tripathi**,(University of Turin), Italy : Resummed Transverse Momentum Distribution of the Higgs Bosons: Summing up a Divergent Series, 26.08.2014

20. **Dr. Prabwal Jyoti Phukan**, PDF : Holographic optics from R-charged black holes, 28.08.2014

21. **Mr.M. C. Kumar** (Univ. of Hamburg) : QCD threshold corrections to inclusive jet production at hadron colliders, 01.09.2014

22. **Dr. S.K. Prasad**, Bose Institute, Kolkata : Jet measurements in pp, p-Pb and Pb-Pb collisions at the LHC, 15.09.2014

23. **Dr. A.K. Nayak**, DESY, Germany : Search for the Higgs boson decaying to a pair of tau leptons at CMS, 16.09.2014

24. **Dr. Sunil Bansal,** University of Belgium, Belgium : Study of the Multiple Parton Interactions using CMS detector, 17.09.2014

. **Dr. Souvik Banerjee,** Groningen, Netherlands : Performing Local Experiments in AdS Black Hole, 19.09.2014

26. **Dr. Sayantan Choudhury**, Indian Statistical Institute, Kolkata : Inflationary model building, reconstruction of parameters and observational bounds, 30.09.2014

27. Dr. Puneet Mishra, Institute of Multidisciplinary Research for Advanced Materials,Tohoku University, Sendai, Japan : Chiral supramolecular motors driven by tunneling current, 30.09.2014

28. Dr. P. Santhana Raman, CIBA,, Department of Physics, National University of Singapore, Singapore : Research and Development with Energetic Broad- and Nano-Ion Beams: From Ion Beam Analysis to Novel Materials Modification and Proton Beam Writing Systems, 01.10.2014

29. Dr. Atanu Maulik, Visiting PDF, IOP : Possible Backgrounds and Shielding Requirements or a Direct Dark Matter Search Experiment, 07.10.2014

30. Dr. S. K. Gupta (Monash University) : A Flavor-violating Higgs Boson at the LHC, 07.10.2014

31. Dr. S. Banerjee (IPMU, Tokyo) : Conformal Anomaly Matching and Exact Results for Entanglement Entropy, 09.10.2014

32. Dr. Dipak Paramanik, Iowa State University, USA. : Fabrication of vertically aligned core-shell nano pilla structure for high sensitive photodetectors, 09.10.2014

33. Dr. Boby Joseph, Elettra-Sincrotrone Trieste, AREA Science Park, 34149 Basovizza, Trieste. Italy : Investigating phase-separation in alkali-metal intercalated iron-chalcogenide superconductors using scanning nano-diffraction and micro x-ray absorption maps, 10.10.2014

34. Dr. Anamitra Mukherji (University of Tennessee, Knoxville) : Auger electron spectroscopy: going beyond the impurity approximation, 15.10.2014

35. Dr.A. Nautiyal (IISER, Bhopal) : Testing theories of Cosmology with Cosmic Microwave Background, 15.10.2014

36. Dr. Arijit Saha (Univ. of Basel) : Transport signatures of Fractional Fermions in Nanowires, 15.10.2014

37. Dr. Saptarshi Mandal (ICTP, Trieste) : Classical ground state spin configuration on hollandite Lattice and its relation with a-MnO_2 system, 16.10.2014

38. Dr. B. Coleppa (Chennai) : Exotic Decays of Heavy Higgs Bosons, 20.10.2014

39. Dr. B. Rakshit, SNBOSE Institute, Kolkata : Structural and electronic properties of Graphene analogue semiconductors, 20.10.2014

40. Dr. Priyotosh Bandyopadhyay (University of Helsinki) : Higgs(es) in Triplet extended supersymmetric standard model at the LHC, 21.10.2014

41. Professor Probir Roy, SINP and Bose Institute) : Testable Constraint on near-tribimaximal neutrino mixing, 21.10.2014

42. Dr. Suman Ganguli, PDF, IOP : Various string configurations on topological black holes, 22.10.2014

43. Soumen Basak (SISSA) : Our Universe according to Planck, 27.10.2014

44. Dr. Subhadip Mitra, Kolkata : Vector-like Quarks in Warped-space Models, 28.10.2014

45. Dr. Tamoghna Das (OIST Graduate University, Japan) : Geometric universality of two-dimensional aggregates, 31.10.2014

46. Dr. Bijan Saha, Joint Institute for Nuclear Research. Dubna, Russia : Spinor field in cosmology: Problems and Possibilities, 10.1.2014

47. Dr. Yashpal Singh Katharria, Department of Physics, Central University of Rajasthan, Bandarsindri, Ajmer : Ion beam synthesis & surface structuring of silicon carbide, 11.1.2014

48. Dr. N. Nirmal Thyagu (MPI, Goettingen, Germany) : Tetrahedra packings: Role of particle shape in mechanical stability and jamming transition, 12.1.2014

49. Prof. Sudipta Mukherji ,IOP : AdS Cosmology and Gauge Theory Correlator: Anisotropic Scaling, 02.12.2014

50. Vandana Yadav (IIT Kanpur) : Study of growth dynamics of microtubules through a boundary-layer based approach, 09.12.2014

51. Dr. Avijit Mishra (HRI) : Quantum Correlation with Sandwiched Relative Entropies, 10.12.2014

52. Prof. Partha Mokhopadhyay : Strings in Curved Space-time and Tubular,Geometry, 12.12.2014

53. Dr. P.S. Bhupal Dev (University of Manchester, UK) : A Flavor and Spectral Analysis of the Ultra-High Energy Neutrino Events at IceCube, 15.12.2014

54. Dr. Chandan Giri, University of Jyväskylä, Finland : Sub-component Self-assembly as a route to Structure to Materials, 22.12.2014

55. Dr. Mona Jani (UNICAMP, Brazil) : Surface modifications, Spectroscopic studies and Biomedical applications of nano-diamonds for imaging and therapy, 29.12.2014

56. Dr. Trilochan Bagarti, Harish-Chandra Research Institute, Chhatnag Road, Jhunsi, Allahabad-211019. : Inhomogeneous reaction-diffusion models, 12.01.2015

57. Dr. Sovan Chakraborty (MPI, Munich) : Physics Opportunities with Supernova Neutrinos, 15.01.2015

58. Mr. Sudhansu Sekhar Das, IIT,Bombay : Anomalous Hall effect Studies in Si/Fe Multilayers and SiO2/Fe/SiO2 Sandwich Structures,15.01.2015

59. Dr Pranati Rath (IIT Kanpur) : Large scale anisotropy in Cosmic Microwave Background Radiation, 21.01.2015

60. Dr Arnab Saha, University of Duesseldorf, Germany : A Complex Fluids: From Driven Colloids To Active Patterns, 21.01.2015

61. Dr. Swapan Majhi, IACS, Kolkata : Higher Order Radiative Corrections in collider physics, 28.01.2015.

62. Dr. Umananda Bhatta ,Jain University, Bangalore : Morphology and Surface Analysis of Ceria Nanoparticles, 30.01.2015.

63. Dr. Tushar Dhabal Das Department of Electronic Science, University of Calcutta : Growth and Characterization of III-V Bismides for near-infrared and mid-infrared devices, 06.02.2015.

64. Prof. R. Palit, TIFR, Mumbai : Exotic Quantal Modes of Nuclei, 9^{TH} – 12^{TH} FEB, 2015

65. Prof. R. Palit, TIFR, Mumbai : Synchronization in coupled oscillator systems in presence of inertia and noise, 11.02.2015.

66. Dr.M. Mahakhud, HRI, Allahabad : Next-to-Next-to Leading Order QCD corrections in models of TeV-scale gravity, 18.02.2015.

67. Dr. Mamata Sahoo (CSIR-NIIST, Trivandrum) : Transcriptional Blockage: A dynamic roadblock in a normal exclusion process, 25.02.2015.

68. Professor M. Sivakumar (School of Physics, University of Hyderabad) : A first introduction to Vasiliev equations, 26.02.2015.

69. Ms. Priyadarshini Dash, Physics Dept.,Utkal University : Microstructural and Topographical Evolution of Gold Thin Films under Thermal Annealing and Swift Heavy Ion Irradiation, 26.02.2015.

70. Dr. M. Mandal, HRI, Allahabad : Threshold corrections to the rapidity distribution in Higgs production at third, order in QCD, 27.02.2015.

71. Dr. Tirtha Som, Institute: Helmholtz Zentrum Berlin for Materials and Energy, Germany : Nanostructured Materials for Energy and Manifold Associated Applications, 27.02.2015.

72. Prof. D. P. Roy, HBCSE, Mumbai : SUSY Dark Matter in Universal and Nonuniversal Gaugino Mass Models, 02.03.2015.

73. Dr. Supravat Karak, Department of Polymer Science and Engineering Conte Research Center Department of Chemistry, Goessman-202 University of Massachusetts 120 Governors Drive Amherst, MA 01003 : Organic Semiconductor Based Plastic Solar Cell: Science, Expectation and Challenges, 02.03.2015.

74. Dr. Srinivas Gadipelli , Department of Chemistry University College London (UCL),London, UK. : Synthesis & Characterization of Functional Materials for Clean Energy & Environment, 02.03.2015.

75. Dr. Satyaprakash Sahoo, Department of Physics, University of Puerto Rico, San Juan, PR, US : Raman Scattering in Two-Dimensional Layered Materials Beyond Graphene, 03.03.2015.

76. Dr. Vijay Raj Singh, Boston University, MA, USA : X-ray magnetic circular dichroism study of oxide-based magnetic materials and half-metallic alloys, 09.03.2015.

77. Anirudha Ghosh, IISER Kolkata : Structural and Magnetic properties of transition-metal doped CdS nanoparticles, 10.03.2015.

78. Dr. Shrawan Mishra, Advanced Light Source, Lawrence Berkeley National Laboratory. : New twist in nano magnetism: A polarized soft X-rays view, 12.03.2015.

79. Dr. Priyotosh Bandyopadhyay, Italy : Higgs(es) in extended super- symmetric standard models at the LHC, 19.03.2015.

80. Dr. Paramita Dutta, SINP, Kolkata : Quantum Transport in Low-dimensional Systems, 24.03.2015.

81. Mr Chaitra Hegde, RRI , Bangalore : Tagged Particle Diffusion in Interacting Particle Systems, 25.03.2015.

82. Dr.Jayeeta Lahiri, School of Physics, University of Hyderabad : Two dimensional graphene and hexagonal BoronNitride films on transition metal surfaces, 26.03.2015.

83. Mr T. Arun, NIT Tiruchirapalli : Prussian blue modified Fe based magnetic nanoparticles, 27.03.2015

84. Dr. Kirtiman Ghosh (Oklahoma State University, USA) : Probing constrained Minimal Supersymmetric Standard Model with top-quark,27.03.2015

85. Dr. Kirtiman Ghosh (Oklahoma State University, USA) : Predictive models for Dirac neutrino mass matrix, 30.03.2015

5.3. LECTURES DELIVERED BY IOP MEMBERS

Dr. A. M. Srivastava

1. **Introduction to topological defects**, at Condensed matter Journal Club, Institute of Physics, May, 2014.

2. **Relativistic heavy-ion collision research in India,** at the India-JINR Forum on Frontiers in Elementary Particle, Nuclear and Condensed Matter Physics", JINR, Dubna, Russia, June'14.

3. **Flow fluctuations in heavy-ion collisions and CMBR anisotropies**, at the India-JINR Forum on "Frontiers in Elementary Particle, Nuclear and Condensed Matter Physics", JINR, Dubna, Russia, June'14.

4. **Investigating Cosmic string theories with Liquid Crystal Experiments,** Frontiers in Physics 2014 conference at Physics Dept. Hyderabad Univ., Oct. 2014.

5. **The universe and dark energy,** Physics Dept., NIT Rourkela, Nov. 2014.

6. **Investigating Cosmic string theories with Liquid Crystal Experiments,** The Annual Function DAE-UGC CSR, Indore, Dec. 2014**.**

7. **Effect of magnetic field on flow fluctuations in relativistic heavy-ion collisions,** The workshop on "Magnetic field and vorticity in heavy-ion collisions, Jan. , 2015, Phys. Dept., UCLA, USA.

8. **Probing dynamics of phase transitions inside pulsar cores,** Phys. Dept. Syracuse Univ. USA, Jan. 26, 2015.

9. **QGP in the universe, from early stages to the present**, at the International conference on Physics and Astrophysics of quark-gluon plasma (ICPAQGP), at VECC, Kolkata, Feb. 2015.

10. **New ideas for signals at LHC and FAIR**, at the discussion meeting at Bose Institute, Darjeeling, 9 Feb. 2015.

11. Chief Guest seminar on "**Our Universe, Elementary Particles, and Dark Energy**" in the Annual Seminar of Ravenshaw University, Cuttack, March 2015.

12. Popular talk on **Stars, Galaxies, and black holes in the universe,** for school students at the Science Fair in the Regional Science Center, Bhubaneswar, May, 2014

13. Popular talk on **Structure of atoms**, for school students at the Science Fair in the Regional Science Center, Bhubaneswar, May, 2014

14. Popular talk on **Indian Scientists and their inventions** at Regional science centre, for school students, Sept. 2014.

15. Popular talk in Hindi on **Brahmand ki Sanrachana (Structure of the Universe)**, at IOP for IOP members, Sept. and Oct. 2014.

16. Popular talk in Hindi on "**Brahmand ki Sanrachana" at Raj Bhasha meeting on the** "Role of science and technology for Made in India" organized by CSIR-IMMT, Bhubaneswar, March, 2015.

Dr. S. Varma

1. **Invited talk on Nanostructures and Nano-Bio studies with Low Energy Ion Beams** at Frontiers in Nuclear, Elementary Particle and Condensed Matter Physics organized by JINR (Joint Institute For Nuclear Research)-India Forum at Dubna, Russia (Jun. 2014).

2. **Invited Lecture on X-ray photoelectron Spectroscopy** at International School on Ion Beams in Material Science, organized by IUAC, New Delhi (Oct 2014).

3. **Invited Talk on Observations of Bandgap Tunability and DNA Biocompatibility on nanostructured TiO2(110) surfaces** at DAE-BRNS National Conference on Current Trends in Advanced Materials, VECC, Kolkata (Nov 2014).

4. **Invited Lectures (seven) on Concepts in Surface Growth, Interfaces in Nature, Scaling and Growth, Scaling Concepts, Fractal Concepts and Random Numbers, X-ray Photoelectron Spectroscopy (XPS), UV Photoelectron Spectroscopy (UPS) and Auger Electron Spectroscopy (AES)** in the DST-SERC School on Ion Interaction with Matter, at Department of Physics, Saurashtra University, Rajkot, Gujrat (March 2015):

5. Review Talk on Academic Activities of Institute of Physics Condensed Matter Physics- Experimental (for period 2010-2014) at External Review meeting (Nov 2014).

Dr. P. Agrawal

1. **Building Blocks of Matter**, in DST Inspire Program at Indic Engineering College, Oct 16-22, 2014.

Dr. P. V. Satyam

1. **Coherent Embedded Nanostructures (Endotaxy) and Their Applications**, DAE Solid State Physics Symposium, VIT, Vellore, 18 December 2014

2. **Real Time XRD - CVD growth of Endotaxial Ag nanostructures**, Advances in Nanomaterials using Synchrotron Techniques (*ANST-2014*), SINP - Kolkatta, December 2014

3. **Electron Microscopy study of epitaxial and endotaxial systems**, International Conference on Electron Microscopy, July EMSI2014, Delhi

4. **Endotaxy : Physics at Low Dimensions,** Symposium, Vidyasagar University, Midnapore, WB, 26 March 2015

5. **Characterization of AlGaInN/GaN Interfaces by Electron Microscopy techniques**, SSPL, DRDO, Delhi, 9th February 2015.

6. **Endotaxy of Silver Nanostructures in Silicon: Growth, Characterization and Applications**, NIMS, Tsukuba, November 2014

7. **Tour to Nanoworld by using Electron Microscopy, National Conference on Advanced Functional Materials and Computer Applications in Materials Technology (CAMCAT-2014),** 18th & 19th December 2014, Visakhapatnam, AP.

8. **Journey to the making of White LED (Nobel Prize in Physics 2014)**, DAE Diamond Jubilee Year Celebrations, Institute of Physics, Bhubaneswar, 1st February 2015 (Popular Lecture).

9. **Seeing is believing: Electron Microscopy**, Govt. college, Anantapur, AP, India, January 24, 2015 (Popular Lecture).

Dr. Sudipta Mukherjee

1. **Some aspects of Field theory**, 3 lectures, Tezpur University January 2015.

2. **Renormalization: toy examples**, 6 lectures, Sambalpur University, January 2015.

3. **Field theory, SERC prep school**, BITS, Hyderabad. 8 lectures, June 2014.

Dr. T. Som

1. **Opportunities and Challenges in Condensed Matter and Materials Physics,** Shiv Nadar University, Greater Noida on April 17, 2014.

2. **Recent Advances in Physics,** Berhampur University, Berhampur on May 05, 2014.

3. National Conference, Condensed Matter Days, Calcutta University, Kolkata on August 27, 2014.

4. International Conference on Swift Heavy Ions in Materials Engineering and Characterization, Inter-University Accelerator Centre, New Delhi on October 15, 2014.

5. National Conference on Current Trends in Advanced Materials, Variable Energy Cyclotron Centre, Kolkata on November 19, 2014.

6. National Conference on Current Trends in Condensed Matter Physics (CTCMP), National Institute of Science Education and Research, Bhubaneswar on February 20, 2015.

7. **Ion-Matter Interaction,** 4- *Lectures*, 1st DST-SERB School on , Saurashtra University, Rajkot on March 12 and March 13, 2015.

Dr. S. B. Ota

1. **Vortex lattice melting in HTSC**, Institute of Physics, 29 May 2014

Dr. Sanjib Agarwalla

1. **Probing Non-Standard Interactions,** Daya Bay Seminar given at the Centre for Theoretical Physics, Jamia Millia Islamia, New Delhi, India, 9th March, 2015

2. **Talking to Neutrinos at the India-based Neutrino Observatory (INO)**, Colloquium given at the Centre for Theoretical Physics, Jamia Millia Islamia, New Delhi, India, 5th November, 2014

3. **Projected Sensitivity from ICAL + LBL Experiments,** INO Collaboration meeting, IICHEP, Madurai, India, 18th September, 2014

4. **Exploring Neutrino Properties at the India-based Neutrino Observatory (INO),** Colloquium, Utkal University, Bhubaneswar, India, 6th September, 2014

5. **Neutrino Properties from Recent Reactor and Accelerator Experiments** , Alumni Day Celebration, Institute of Physics, Bhubaneswar, India, 3rd September, 2014

6. **Recent Developments in Neutrino Oscillations & Future Roadmap,** TIFR, Mumbai, India, 22nd August, 2014

7. **Enhancing Sensitivity to Neutrino Parameters with Inelasticity measurement in Atmospheric Neutrinos,** ICAL-INO Seminar given at IFIC, University of Valencia, Valencia, Spain, 10th July, 2014

8. **India-based Neutrino Observatory (INO),** ICHEP 2014 Conference, Valencia, Spain, 4th July, 2014

9. **Implications of Recent Measurements in Neutrino Sector & Future Directions**, Colloquium, APC Laboratory, Paris, France, 27th June, 2014

10. **Overview of Currently Running Reactor and Accelerator Experiments Invited plenary,** Global Neutrino meeting, Paris, France, 23rd June, 2014

Dr. P. K. Sahu

1. **Nuclear Heavy-ion Collisions and Astrophysics,** Gandhi Institute Of Excellent Technocrafts(GIET), Ghangapatna, Bhubaneswar-752054 on 21st March, 2015.

2. **Statistical Significance of Mass Hierarchy in Future Experiments Invited plenary,** INO Collaboration meeting, VECC, Kolkata, India, 5th April, 2014

Prof. J. Maharana Lecture

Leggett-Garg Inequalities and Device-Independent Randomness, Physical Research Laboratory, Ahmedabad, During May,2014.

Sabita Das

Identified Particle Production and freeze-out properties in heavy-ion collisions in RHIC BES program, International Symposium of Multi-particle Dynamics , Bologna, Italy (Sept. 8-12, 2014).

Pramita Mishra

Electronic structure of HOPG by ARPES, International Conference on Physics at Surfaces and Interfaces (PSI-2014) 24-28 February 2014, Puri, Odisha.

Sabya Sachi Chatterjee

1. **CP Asymmetry in Neutrino Oscillation**, Institute of Physics, Bhubaneswar, 11th June, 2014.

2. **Long-Range Forces in Long-Baseline Neutrino Oscillation Experiments**, XXI DAE-BRNS High Energy Physics symposium 2014, 08-12 December, 2014, IIT Guwahati.

3. **Neutrinos: A New Window to our Universe**", DAE-IOP Science Outreach Program on 1st Feb, 2015 at IOPB.

Bidisha Chakraborty

1. **Geroch group description of Black holes**, Tata institute of Fundamental Research, Mumbai, India, May 5 2015.

2. **Geroch group description of Black holes**, Indian Strings Meeting, Puri, India, Dec 17 2014.

3. **Geroch group description of Black holes**, Field theoretic aspects of Gravity, IISER, Mohali, Dec 11 2014.

4. **Applications of Kaluza Klein theories to black holes**, Indian Institute of Science, Bengaluru, Nov 2014.

Dr. S. N. Sarangi

1. **Selective Growth of ZnO Nanostructures by the Hydrothermal Technique: An Efficient Alcohol Sensor,** The 3rd International Conference on Nanoscience and Nanotechnology (ICONN 2015) at SRM University, Chennai.

5.4. CONFERENCE / WORKSHOP ATTENDED BY IOP MEMBERS

Dr. A. M. Srivastava

1. India-JINR Forum on “Frontiers in Elementary Particle, Nuclear and Condensed Matter Physics”, JINR, Dubna, Russia, June’14.
2. Frontiers in Physics 2014 conference at Physics Dept. Hyderabad Univ., Oct.2014

3. International Workshop on “Magnetic field and vorticity in heavy-ion collisions, Jan, 2015, Phys. Dept., UCLA, USA.

4. International conference on Physics and Astrophysics of quark-gluon plasma (ICPAQGP)”, at VECC, Kolkata, Feb. 2015.

Dr. S. Varma

1. Frontiers in Nuclear, Elementary Particle and Condensed Matter Physics organized by JINR (Joint Institute For Nuclear Research)-India Forum at Dubna, Russia (Jun. 2014).

2. International conference on Ion Beams in Material Science‘, organized by IUAC, New Delhi (Oct 2014).

3. DAE-BRNS National Conference on Current trends in Advanced Materials‘, VECC, Kolkata (Nov 2014).

Dr. P. V. Satyam

1. DAE Solid State Physics Symposium, VIT, Vellore, 18 December 2014

2. Advances in Nanomaterials using Synchrotron Techniques (*ANST-2014*), SINP - Kolkatta, December 2014

3. International Conference on Electron Microscopy, July EMSI2014, Delhi

4. National Conference on Advanced Functional Materials and Computer Applications in Materials Technology (CAMCAT-2014) 18th & 19th December 2014, Visakhapatnam, AP

5. 2nd National Workshop on III-Nitride Materials and Devices, SSPL/DRDO, New Delhi, 9-10th February 2015

6. Physics at Low Dimensions Symposium, Vidyasagar University, Midnapore, WB, 26 March 2015

Dr. T. Som

1. National Conference on Opportunities and Challenges in Condensed Matter and Materials Physics, Shiv Nadar University, Greater Noida on April 17, 2014.

2. National Seminar on Recent Advances in Physics, Berhampur University, Berhampur on May 05, 2014.

3. National Conference, Condensed Matter Days, Calcutta University, Kolkata on August 27, 2014.

4. International Conference on Swift Heavy Ions in Materials Engineering and Characterization, Inter-University Accelerator Centre, New Delhi on October 15, 2014.

5. National Conference on Current Trends in Advanced Materials, Variable Energy Cyclotron Centre, Kolkata on November 19, 2014.

6. National Conference on Current Trends in Condensed Matter Physics (CTCMP), National Institute of Science Education and Research, Bhubaneswar on February 20, 2015.

Dr. P. K. Sahu

1. Attended the "7th Internation Conference on Physics & Astrophysics of Quark Gluon Plasma", 2-6 February 2015, VECC, Kolkata, India.

2. Indian Strings Meeting, Puri, December 2014. 3. Field Theoretic Aspects of Gravity, IISER Mohali, Puri 2014. D. Black Holes in String Theory

3. Physics Colloquium, IISER Bhopal, October 2014

4. UGC-DRS National Seminar on 100 years of General Theory of Relativity, Utkal University, March 2015.

Dr. A. Virmani

1. International Max Planck Research School for Geometric Analysis, Gravitation and String Theory, Max-Planck-Institute for Gravitationsphysik (Albert Einstein Institute) July 2014

2. Advanced String School, co-organized with Sudipta Mukherji, September 2014, Puri.
3. Organizing Committee member of Indian Strings Meeting, December 2014, Puri.

4. Organizing Committee member of FTAG, Field Theoretic Aspects of Gravity, December 2014, IISER Mohali.

5. Workshop on black objects beyond supersymmetry, Utrecht University, the Netherlands, September 2014

6. Indian Strings Meeting, Puri, December 2014

7. Field Theoretic Aspects of Gravity, IISER Mohali, Puri 2014

8. Kavli Institute of Theoretical Physics China, Beijing, July 2014

9. Indian Institute of Sciences, Centre of High Energy Physics, Bangalore October 2014

10. Kavli Institute of Theoretical Physics China, Beijing, July 2014.

11. International Solvay Institutes, Brussels, May 2014.

12. Ecole Polytechnique, Paris, May 2014.

13. Institute Tecnico Superior, Lisbon, June 2014.

14. University of Groningen, the Netherlands, May 2014. B. Inverse Scattering Construction of the JMaRT Fuzzball

Dr. S. K. Agarwalla

1. India-based Neutrino Observatory (INO) collaboration meeting, VECC, Kolkata, India, 3rd-5th April, 2014

2. International meeting for Large Neutrino Infrastructures, Paris, France, 23rd - 24th June, 2014

3. 37th International Conference on High Energy Physics (ICHEP 2014), Valencia, Spain, 2nd -9th July, 2014

4. DAE-DST Vision meeting on Nuclear, Particle, and High Energy Physics, BARC/ HBCSE, Mumbai, India, 24th-25th August, 2014

5. India-based Neutrino Observatory (INO) collaboration meeting, IICHEP, Madurai, Tamil Nadu, India, 18th-20th September, 2014

5.5. AWARDS / HONOURS AND RECOGNITIONS

Prof. S. Panda

1. Elected as Fellow of Indian National Science Academy (INSA) [Effective from 01 January 2015].

Dr. S. K. Agarwalla

1. Appointed as Simons Associate of The Abdus Salam International Centre for Theoretical Physics (ICTP) from 1st January 2015 to 31st December, 2020.

2. Awarded with the National Academy of Sciences (NASI) - Young Scientist Platinum Jubilee Award (2014).

3. Awarded with the Indian National Science Academy (INSA) Medal for Young Scientists - 2014

Sabita Das

1. Her poster presentation was awarded as the best poster in International Symposium of Multi-particle Dynamics, Bologna, Italy, Sept. 8-12, 2014.

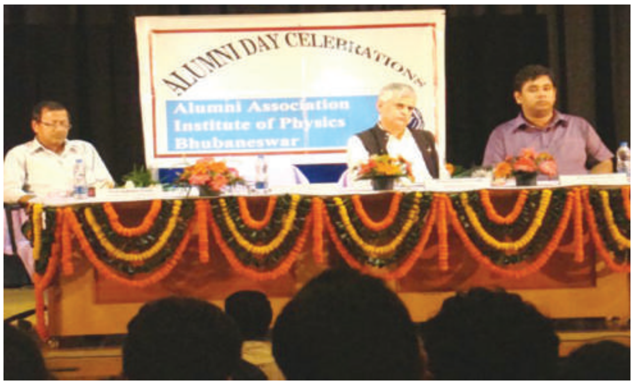
6

CONFERENCE & OTHER EVENTS

School Students receiving Awards from Chief Guest of Alumni Function

Organising Members of Alumni Day Function

6.1 ALUMNI DAY



The 35th Alumni Day was celebrated on 3rd September, 2014. Headed by Prof. S. Panda, Director as President of the Alumni activities of the Institute. 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, we had organised many lectures viz. Aswini Kumar Rath Memorial talk delivered by Prof. Satyaki Bhattacharya, SINP, Kolkata. The Alumni day lectures by eminent Scientist / Alumni members. Prof. Bikash Chandra Gupta, Viswa-Bharati University delivered Alumni Talk entitled " Free and supported nano-structures : Structural, Electrical and Magnetic properties. Distinguished scientist Prof. Amitava Raychaudhuri of Calcutta University delivered the Coolquium talk entitled "*Exploring the known unknowns of neutrino physics*" on the eve of morning session of the Alumni Day function of the Institute.

The evening program started with prize distribution to the winners of various competitions such as debate, science modeling and many other competition organised by the Alumni association of the IOP, the year-long program. It was followed by a talk by Eminent Journalist, Mr. Palagummi Sainath entitled *"Rural India crisis and Inequalities"*. This was followed by Excellent Orchestra and fusion performed by Nigam Flute Academy. This followed by the evening cultural programe. Bharatnatyam, Kuchupudi and Mohininatyam by Kalamandalam, Kolkata.

Office Bearers :

Secretary	:	Mr. Priyo Shankar Pal
Asst. Secretary	:	Ms. B. Chakrabarty
Treasurer	:	Mr. Puspendu Guha
Faculty Advisor	:	Dr. S. Agarwalla

Chief Guest of Alumni Day addressing the audience

Cultural Program

6.2. FOUNDATION DAY

Prof. S. Panda, Prof. A. Raychaudhuri and Prof. B. R. Sekhar

The 40th Foundation Day of the Institute was celebrated on September 4, 2014 (Thursday). 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. This year the Chief Guest was Prof. Amitava Raychaudhuri, Sir Tarak Nath Palit Professor of Physics, University of Calcutta.

Prof. S. Panda, Director and Prof. A. Srivastava during a sweet moment of Foundation day-2014

Prof. Raychaudhuri delivered the Foundation Day talk titled " *What drives Scientific Progress?"*. 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.

Prof. Raychaudhuri is delivering Foundation Day Talk

On this eve Prof. Raychaudhuri delivered a popular Talk.

6.3. FREE EYE TESTING CAMP :

A free eye testing camp for two days was organized by the Institute for the staff members, scholars, visiting scientist and their family members of IOP and NISER during 24th and 25th January, 2015. This eye camp organized jointly by Lawrence & Mayo, a leading manufacturer of lens in India and Institute of Physics.

Successfull Predoctoral Scholar receiving their certificates from Chief Guest ; Chandan Datta, Bharat Kumar, Ashish K. Manna, Praonoy Nandi, Paramita Maiti, Ranveer Singh, Debashis Saha, Mahesh Saini and Arpan Das

Director Along with the organizing member of Foundation Day from Scholar Side

6.4. ADVANCED STRING SCHOOL

Advanced String School *(fifth in the series)* has been organized from September 22 to September 28, 2014. The aim of the school was to stimulate scientific interactions between students and teachers from international community while contributing to the development of scientific research in India. The school, in particular, was for the graduate students and the postdocs in India working in String Theory. Permanent faculty members were also attended the school. The school was open to all from the national and international community working in String Theory as well.

Director is delevering a talk in Advanced String School on 28.09.2014

Participants of Advanced String School

7

OUTREACH

The Outreach Program of the Institute of Physics is aimed at spreading scientific awareness among common people, especially regarding various research activities being carried out at the Institute. The special focus of the program is on school children, involving them in various scientific programs to generate their interest in basic sciences and stimulate scientific thinking. The program is carried out by a joint committee of the Institute of Physics and the National Institute of Science Education and Research.

As a part of the Outreach Program of the Institute of Physics, following programs were carried out.

7.1. DAE Diamond Jubilee Celebration

To celebrate the Diamond Jubilee year of the Department of Atomic Energy (DAE), Government of India, a one-day long Science Outreach Program was organized by the Institute of Physics (IOP), Bhubaneswar on 1st February, 2015. The goal of the program was to provide the opportunity to the bright young minds of the Bhubaneswar city to interact with well known scientists. Nearly 250 students (mostly between IX-XII standards) from 20 schools, 50 science undergraduate students from 5 colleges, 25 school students from IOPB adjacent areas and IOP colony took part in the day long program. One teacher from each school/college also accompanied the students.

Coordinator Dr. S.K. Agarwalla addressing the audience

The program began with the welcome addresses by Professor Sudhakar Panda, Director of the Institute of Physics, Bhubaneswar and Professor V. Chandrasekhar, Director of NISER, Bhubaneswar. There were three science lectures during the course of the day covering topics in nuclear power, LED, and particle physics. Dr. Sanjib Kumar Agarwalla (Reader - F) of this Institute was the co-ordinator of this celebration.

The first speaker was Mr. Swapnesh Kumar Malhotra, Head, Public Awareness Division of the DAE. He spoke about “Nuclear power – the need, the public perceptions, and the realities”. The students could have a good overview on nuclear power production and proper nuclear waste-disposal. The speaker also addressed general issues on public perceptions and misunderstandings of nuclear energy. The talk was followed by a discussion session focussed on this lecture.

The second lecture was by Professor Parlapalli V. Satyam from the Institute of Physics, Bhubaneswar. He spoke about the white LED (Light Emitting Diode), that was the subject of the Nobel Prize in Physics, 2014. He illustrated the basic physics surrounding the working of a LED, its applications in illuminations and emphasized on its low power consumption. The speaker also gave some live demonstrations such as the single slit experiments showing diffraction of light as part of his lecture. This talk was also followed by a discussion session.

The third lecture was based on the fundamental particles of the Nature by Professor Palash Baran Pal from Saha Institute of Nuclear Physics, Kolkata. He motivated students to explore the mysterious world of particle physics by introducing the concept of elementary constituents and how compound objects can be made from them. He then spoke about studying the properties of such elementary particles through particle-collider experiments. He ended the talk by introducing the India-based Neutrino Observatory (INO) project and encouraged the students to take part in this exciting project. All the three talks were well received by the students and they interacted enthusiastically with the speakers after each presentation. After the last talk, there was an open discussion session where the students could ask their doubts in any language to all the three speakers and the scientists of the institute. Apart from the three talks, there were posters set up by doctoral scholars of IOP and they were also present to explain their research work to the students in a simplified fashion and to clarify their doubts.

A well organized science kit was given to each participating student. It contained a bar magnet (50 mm), magnetic compass (20 mm), a convex lens (focal length 15 cm), astronomy 3D Mars cards, exercise book with periodic table etc. Inside the science kit bag, there were instruction manuals on how to make best use of the materials provided as well as information brochures on DAE, IOP, NISER etc. Each participant was also provided with breakfast and lunch during the day and a participation certificate was given to the each student at the end of the program.

Director along with the Chief Guests in the Press Meet

There was also a strong contingent from the local media present during the program and a press conference was held at the end where the media persons got the opportunity to interact with the speakers. The program got a wide coverage on several local newspapers the next day and the Doordarshan Oriya also telecast an edited version of the program on 15th and 17th February, 2015.

Overall there was a huge positive response from the participants. Many of the students (even some parents and teachers) expressed their gratitude over phone or via e-mail, and told that they benefitted hugely by getting this chance to listen to and interact with scientists involved in cutting edge research in various frontier disciplines, an opportunity that they do not get on a daily basis. The whole program was funded by the DAE and the faculty, research scholars, and administrative stuff from IOP all played their part to make this program a success.

7.2. National Science Day

National Science Day was celebrated at the Institute of Physics on 28th March 2015 (due to various constraints of school timings and classes etc.). This was jointly organized by the Institute of Physics and National Institute of Science Education and Research, Bhubaneswar. The program was attended by about 200 school students from Bhubaneswar (both English medium and Oriya medium schools). In addition, about 35 students from IOP/NISER, and the local Basti participated in the program. The program started at 10:00 a.m. with following popular level talks (in English/Oriya) at the Institute Auditorium.

1. Talk on “Evolution of the Universe” by Prof. L.P. Singh, Professor (Retd.), Physics Dept. Utkal University.

2. Talk on “Insects: Our VIPs (Very Important Pests)” by Prof. Subrata Tripathi, Professor (Retd.) TIFR, Mumbai.

Following this, student visits were arranged, in small groups, to IOP experimental facilities, as well as Demonstration Experiments at NISER Labs. There was a very enthusiastic participation of NISER students/faculty in arranging these demonstrations (for Physics, Chemistry, Mathematics, and Biology), and also by IOP research scholars/faculty and scientific assistants in explaining various experimental facilities to school students. The program ended at 5:30 p.m.

7.3 Night sky viewing Session

Night sky observation session was carried out at IOP (on 26th Nov. 2014) for IOP/NISER members and their families using two telescopes. Objects viewed were, Moon, Uranus, Mars, Andromeda Galaxy, and Orion Nebula.

7.4. Programmes for School students

7.4.1. Science Outreach program at Salipur, Odisha *(a small village of coastal Odisha).*

There was a Science Outreach program organized by IOP in collaboration with SCAAA, at Machhuati, Salipur, Odisha on 21st Feb. 2015. Popular level lectures were given for school students and a night sky viewing session was organized using a telescope and binoculars.

7.4.2. 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.

7.4.3. Social outreach

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

Telescope making workshop arrenged at IOP, BBSR

Science Outreach programe in Salipur Village, Odisha.

Free Primary Education to Children of BPL family near IOP.

Science Modelling Competition organized at IOP.

8

OTHER ACTIVITIES

(L - R) Chief Guest Dr. Behera, IMMT, BBSR, Prof. S. Panda, Director IOP and Dr. S.K. Patra, IOP on eve of Children's Day 2014

Cultural Programs on Children's Day - 2014

8.1. Implementation of Official Language Act. :

Hindi is the Official Language of the Union of India and Government Policy aims at progressively increasing the use of Hindi in official work. Effective steps were taken during the year in the Institute to ensure implementation of the annual programme and compliance with the various orders of the Government of India on the recommendations of the Committee of Parliament on Official Language. Major achievements in implementation of the Official Language Policy in the Institute are as follows :

The Official Language Implementation Committee in the Institute has been constituted under the chairmanship of Registrar. Quarterly meeting of the committee were held on 24.03.2015, 24.12.2014 & 25.07.2014 and important decisions for use of Hindi in official work have been taken. Effective steps for ensuring compliance of the decisions have also been taken.

Hindi Fortnight was celebrated from 12th September 2014 to 29th September 2014 in the Institute. To encourage and motivate the employees for doing official work in Hindi, various competitions like Hindi Essay, Hindi Letter Writing, Hindi Noting & Drafting, Hindi Debate, Hindi Translation etc were organized. A Hindi Vaiganik Varta was also organized during this period. A large number of employees participated in these events with enthusiasm. The messages of the Hon'ble Home Minister, Govt. of India and the Chairman, Atomic Energy Commission on the occasion of Hindi Diwas-2014 were read out and circulated. On the occasion of closing of the fortnight, a function was organized on 29.09.2014, in which Director, Registrar, Faculty Members, Scholars and Employees were present. In this function, prizes and certificates were distributed the winners of various competitions.

The World Hindi Day was also celebrated on 10.01.2015 in the Institute. In order to ensure compliance with the Official Language Policy, monitoring is done the different sections. To help the officers/employees in the working of implementation of Official Language Policy Hindi Workshops/ Training/ Rajbhasha Varta were regularly conducted in the Institute.

There are 04 employees under the incentive scheme for doing original noting and drafting in Hindi were awarded.

There are 10 employees were imparted training in Hindi course conducted by the Hindi Teaching Scheme, Department of Official Language, Govt. of India.

Hindi Books worth Rs.8000/- were purchased . A Scientific Seminar in Hindi was organized on 27.03.2014 in the title " Role of Science & Technology for making India" with other R & D institutions established in Bhubaneswar.

8.2. The Women's Cell at IOP :

The Women's Cell (TWC) 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. Following the 1997 Supreme Court judgment in the case of Vishaka and others versus the State of Rajasthan, 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 by taking all steps required, and to be proactive by developing a conducive atmosphere on the campus, where women can work safely with dignity and without any Discrimination.

The objectives of the TWC are:

1. Prevent gender discrimination and sexual harassment, by promoting gender amity amongst all members;
2. Make recommendations to the Director for changes/elaborations in the Rules, Standing orders and Bye-Laws etc, to make them gender just and to lay down procedures for the prohibition, resolution, settlement and prosecution of acts of sexual harassment by and of IOP members;
3. Deal with cases of sexual harassment, in a time bound manner, aiming at ensuring support services to the victimized and termination of the harassment;
4. Recommend appropriate punitive action against the guilty party to the Director.

The main functions of the TWC are:

1. Promotion of Gender amity : Providing information/consultation on gender amity to any student or members;
2. Programmes concerning women's welfare: Bring out publications/posters on promoting gender amity and preventing gender discrimination and sexual harassment at work place;
3. Documentation and Dissemination: Notice board and web page provide everyone with names and phone extensions of the TWC members;
4. 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. Submits a report to the Director, recommending appropriate punitive action against the accused found guilty;

The Constitution of TWC is:

Prof. Shikha Varma,IOP : Chairperson
Members are :
Dr. Debsmita P. Alone, NISER
Dr. Rooplekha Khuntia, NISER
Dr. Bishnu C. Parija, Off. Registrar, IOP
Smt. Nageswari Majhi, SA-C, IOP

8.3 Implementation of Swachh Bharat Mission

As per directives of the Department of Atomic Energy, Swachh Bharat Abhiyan has been launched at this Institute. The Swachh Bharat Mission (SBM) program started at the Institute on 2nd October 2014. Prof. Sudhakar Panda, Director of the Institute has inaugurated the SBM program. All the IOP staff members, students joined the SBM program. On this occasion, Prof. Sudhakar Panda, Director administered "Cleanliness Oath" to all the employees as well as students at 9.30 AM. Thereafter the staff members voluntarily carried out cleaning of office, laboratory and Institute premises including residential colony.

The un-cleaned area near areas of the play ground, parking place, main building, library building, hostel and residential areas have been cleaned on 29.01.2015. On 09.02.2015 all the staff members attended the SBM activities such as cleaning of hostel premises, sweeping of surroundings of Guest House building, removing of junk/ metal/ left over construction materials near the Canteen and Workshop areas.

8.4 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 all the members physically fit. To carry out different sports and cultural activities a committee was formed.

The sports and cultural committee members are: Dr. Suresh Kumar Patra (Chairman), Dr. Tapobrata Som, Mr. Dillip Kumar Chakraborty, Mr. Santosh Kumar Choudhury, Mr. Prabhat Kumar Bal, Mr. Sahadev Jena, Mr. Anjan Bhukta, Mr. Subhasish Rana and Mr. Balakrushna Dash (Secretary). Following are the different activities conducted during the year 2014-15:

1. A Football match was conducted on 15th August, 2014. This was a friendly match between Director's Team (Faculties, Doctorial Scolars) and Registrar's Team (Staff) of the Institute. Director's Team won the match. Dr. Tanmoy Basu was the captain of the Champion team and Mr. Brundaban Mohanty was the captain of the runner's team. Around 100 spectators were there to enjoy the football match.

IOP participants of Zonal Selection - Kabaddi

2. A friendly Cricket match was conducted on the occasion of 26th January, 2015. 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 make the event successful.

3. Social activities generate a lot of interest and pleasure among staffs and their dependants. For this purpose a program was organized on 14th November, 2014 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 showed their art in front of 300 viewers in the IOP auditorium.

4. Institute also organized the Annual Sports and Cultural Meet in the month of August, 2014. These events started on 23.08.2015 and got completed on 04.09.2015. The total numbers of events were 17. Around 60 staff members participated in Gents group, 30 family members participated in the Ladies 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 silver medals in the Annual day program.

5. In the year 2014-15, Institute conducted one DAE Sports and Cultural meet selection trial match i.e. Kabaddi on 03.01.2015. Kabaddi teams from different DAE units participated in the match. The teams were (1) UCIL, Jaduguda (2) HWPB, Talcher (3) AMD, Jamsedpur and (4) IOP, Bhubaneswar.

Among 44 players, 13 players were selected to participate in NAPS, Narora to play the final matches. Mr. Brundban Mohanty, Mr. Pramod Kumar Senapati and Mr. Nabakishore Jhankar were selected to play the final match for the Konark Team.

In addition to Kabaddi match, Mr. J.K.Mishra and Mr. Pabani Bastia were also selected to go to BARC, Mumbai to play the final match of Bridge, after playing the trial match at HWB, Talcher.

Cultural Programme on eve of Children's Day 2014

9

PERSONNEL

9.1 LIST OF INSTITUTE MEMBERS

Prof. Sudhakar Panda
Director
Theoretical High Energy Physics

A. Faculty members and their research specialisation

1. **Arun M. Jayannavar**
Sr. Professor
Condensed Matter Physics (Theory)

3. **S. M. Bhattacharjee**
Sr. Professor
Condensed Matter Physics (Theory)

5. **Shikha Varma**
Professor
Condensed Matter Physics (Experiment)

6. **Ajit M. Srivastava**
Professor
High Energy Physics (Theory)

7. **Pankaj Agrawal**
Professor
High Energy Physics (Theory)

8. **Biju Raja Sekhar**
Professor
Condensed Matter Physics (Experiment)

9. **P. V. Satyam**
Associate Professor
Condensed Matter Physics (Experiment)

10. **Snehadri B. Ota**
Reader - F
Condensed Matter Physics (Experiment)

11. **Sudipta Mukherji**
Professor
High Energy Physics (Theory)

12. **Suresh K. Patra**
Associate Professor
Nuclear Physics (Theory)

13. **Tapobrata Som**
Associate Professor
Condensed Matter Physics (Experiment)

14. **Goutam Tripathy**
Reader-F
Condensed Matter Physics (Theory)

15. **Pradip Kumar Sahu**
Associate Professor
Nuclear Physics (Theory)

16. **Dinesh Topwal**
Reader - F
Condensed Matter Physics (Experiment)

17. **Amitabh Virmani**
Reader - F
High Energy Physics

18. **Sanjib Kumar Agarwalla**
Reader - F
High Energy Physics

B. Post-Doctoral Fellows

1. Natasha Sharma *(upto 22.07.14)*
2. Soumya Saswati Sarangi *(upto 25.07.14)*
3. Padmanabhan B. *(upto 08.08.14)*
4. Mrutyunjaya Bhuyan *(upto 11.09.14)*
5. Prabwal J. Phukon *(upto 21.10.14)*
6. Siba Prasad Das *(upto 28.11.14)*
7. Debi Prasad Datta *(upto 09.02.15)*
8. Raghavendra Rao Juluri *(from 20.08.14)*
9. Suman Ganguli
5. Atanu Maulik
9. Somnath De
11. Bipul Rakshit
13. Chandan Giri

C. Research Associate

1. Sujit K. Choudhury *(Sr. Res. Associates)*
2. Tanmoy Basu *(from 01.08.15)*
3. Indrani Mishra *(from 01.08.15)*
4. Partha Bagchi *(from 01.08.15)*
5. Rama Chandra Baral *(from 01.08.15)*
6. Sabita Das *(from 01.08.15)*
7. Subhashis Rana *(from 01.08.15)*
8. Tanmoy Pal *(from 01.08.15)*

C. Teaching Assistant

1. Pramita Mishra *(from 01.08.15)*
2. Vanaraj J. Solanki *(from 01.08.15)*

E. Doctoral Scholars

1. Anjan Bhukta
2. Arnab Ghosh
3. Himanshu Lohani
4. Mohit Kumar
5. Shailesh Kumar Singh
6. Shailik Ram Joshi
7. Sk. Sazim
8. Subhadip Ghosh
9. Arpan Das
10. Sumit Nandi
11. Soumyarata Chatterjee
12. Subrata Kumar Biswal
13. Bidisha Chakrabarty
14. Priyo Shankar Pal
15. Puspendu Guha
16. Sabya Sachi Chatterjee
17. Shreyansh Shankar Dave
18. Sudipta Mahana
19. Arpan Das *(Junior)*
20. Ashis Kumar Manna
21. Bharat Kumar
23. Chandan Datta
24. Debashis Saha
25. Mahesh Saini
26. Paramita Maiti
27. Pronoy Nandi
28. Ranveer Singh

F. Pre-doctoral Scholars

1. Mr. Amit Kumar
2. Mr. Biswajit Das
3. Mr. Debashis Mallick
4. Mr. Ganesh Chandra Paul
5. Mr. Partha Paul
6. Mr. Pratik Roy
7. Mr. Sujay Shil
8. Mr. Vigigiri Vikas

G. Administration

Dr. B. C. Parija, Officiating Registrar.

(i) Director's Office:

1. Sk Kefaytulla
2. Raja Kumari Patra
3. Rajesh Mohapatra
4. Rajan Biswal
5. Sudhakar Pradhan *(from 03.04.2014)*

(ii) Registrar's Office

1. Bira Kishore Mishra
2. Abhimanyu Behera

(iii) Establishment

1. M.V. Vanjeeswaran
2. Jaya Chandra Patnaik
3. Sahadev Jena
4. Bhagaban Behera
5. Prativa Choudhury
6. Soubhagya Laxmi Das
7. Samarendra Das

(iv)Stores & Transport

1. Pramod Kumar Senapati
2. Sadananda Pradhan
3. Sanatan Jena
4. Sarat Chandra Pradhan
5. Sanatan Das

(v) EPABX

1. Srikanta Rout

(vi)Despatch

1. Krushna Chandra Sahoo

(viii)Accounts

1. Ranjan Kumar Nayak
2. Pravat Kumar Bal
3. Kali Charan Tudu
4. Jitendra Kumar Mishra
5. Bhaskara Mishra
6. Baula Tudu
7. Aviram Sahoo
8. Priyabrata Patra
9. Chandramani Naik
10. Bansidhar Panigrahi

(ix)Maintenance

1. Arun Kanta Dash
2. Subhabrata Tripathy
3. Patita Sahu *(Upto 30.09.2014)*
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
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. Kapilendra Pradhan
19. Martin Pradhan

(x) Estate Management

1. Ghanashyam Naik
2. Dhobei Behera
3. T. Ramaswamy
4. Gangadhar Hembram
5. Tikan Kumar Parida
6. Kailash Chandra Naik
7. Banamali Pradhan
8. Gokuli Charan Dash
9. Biswanath Swain
10. Bijoy Kumar Swain
11. Bijoya Kumar Das
12. Babuli Naik
13. Pradip Kumar Naik
14. Meena Dei
15. Sudhakar Pradhan
16. Sanatan Pradhan
17. Bhaskara Mallick
18. Kulamani Ojha
19. Pitabas Barik
20. Dhoba Naik
21. Charan Bhoi
22. Jatindra Nath Bastia
23. Basanta Kumar Naik

(xi) Library

1. Prafulla Kumar Senapati
2. Dillip Kumar Chakraborty
3. Ajita Kumari Kujur
4. Duryodhan Sahoo
5. Rama Chandra Hansdah
6. Rabaneswar Naik
7. Kisan Kumar Sahoo
8. Sri Kailash Chandra Jena

(xii) Computer Centre

1. Bishnu Charan Parija
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. Arakhita Sahoo
11. Bala Krushna Dash
12. Soumya Ranjan Mohanty
13. Kshyama Sagar Jena
14. Nityananda Behera
15. Purna Chandra Marndi
16. Srikanta Mishra
17. Ranjan Kumar Sahoo

(xiv) Workshop

1. Ramakanta Nayak
2. Rabi Narayan Naik

9.2. LIST OF RETIRED MEMBERS

Shri Nityananda Behera

Date of Retirement - 30.06.2014
Date of Joining - 01.02.1977
Last Post Hold - Tradesman - D

Shri Patita Sahu

Date of Retirement - 30.09.2014
Date of Joining - 25.05.1982
Last Post Hold - Tradesman - F

Shri T. Ramaswamy

Date of Retirement - 19.09.2014 (VRS)
Date of Joining - 29.04.1982
Last Post Hold - Helper - D

Shri C. B. Mishra

Date of Retirement - 05.11.2014 (CR)
Date of Joining - 01.08.2001
Last Post Hold - Registrar

Shri Duryodhan Sahoo

Date of Retirement - 31.01.2015
Date of Joining - 09.09.1974
Last Post Hold - Tradesman - G

Dr. B. C. Parija

Date of Retirement - 31.03.2015
Date of Joining - 16.02.1995
Last Post Hold - SO-F /
Officiating Registrar *(From 24.04.2014)*

10 AUDITED STATEMENT OF ACCOUNTS

10.1. Balance Sheet

INSTITUTE OF PHYSICS, BHUBANESWAR

BALANCE SHEET AS AT 31ST MARCH 2015

(Amount - Rs.)

CORPUS/ CAPITAL FUND AND LIABILITIES	Schedule	Current Year	Previous Year
CORPUS/ CAPITAL FUND	1	52,64,34,053	55,57,68,545
EARMARKED/ ENDOWMENT FUNDS	2	1,49,700	1,57,696
CURRENT LIABILITIES AND PROVISIONS	3	27,33,80,525	18,61,35,692
TOTAL		**79,99,64,278**	**74,20,61,933**
ASSETS			
FIXED ASSETS	4	65,52,72,750	67,84,17,971
CURRENT ASSETS, LOANS, ADVANCES ETC.	5	14,46,91,528	6,36,43,962
TOTAL		**79,99,64,278**	**74,20,61,933**
SIGNIFICANT ACCOUNTING POLICIES	19		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS			

In terms of our report of even date annexed

For LAL DASH & CO
Chartered Accountants

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

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

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

Place : Bhubaneswar
Date : 11-09-2015

10.2. Income & Expenditure Account

INSTITUTE OF PHYSICS, BHUBANESWAR

INCOME AND EXPENDITURE ACCOUNT FOR THE PERIOD/YEAR ENDED 31ST MARCH 2015

(Amount - Rs.)

INCOME	Schedule	Current Year	Previous Year
Grants/ Subsidies	6	19,71,97,434	15,51,68,889
Interest Earned	7	24,45,529	19,21,758
Other Income	8	17,15,735	12,40,542
Profit on Sale of Asset		35,000	-
TOTAL (A)		**20,13,93,698**	**15,83,31,189**
EXPENDITURE			
Establishment Expenses	9	12,59,08,173	19,76,05,560
Other Administrative Expenses etc.	10	7,60,98,097	6,58,50,762
Depreciation	4	7,14,47,263	7,16,18,680
Loss of Assets		-	-
TOTAL (B)		**27,34,53,533**	**33,50,75,002**
Balance being excess of Expenditure over Income (B-A)		(7,20,59,835)	(17,67,43,813)
BALANCE BEING SURPLUS/(DEFICIT) CARRIED TO CORPUS/ CAPITAL FUND		**(7,20,59,835)**	**(17,67,43,813)**
SIGNIFICANT ACCOUNTING POLICIES	19		
CONTINGENT LIABILITIES AND NOTES ON ACCOUNTS			

In terms of our report of even date annexed

For LAL DASH & CO
Chartered Accountants

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

ACCOUNTS OFFICER
INSTITUTE OF PHYSICS
BHUBANESWAR

DIRECTOR
INSTITUTE OF PHYSICS
BHUBANESWAR

Place : Bhubaneswar
Date : 11-09-2015

10.3. Receipts & Payments

INSTITUTE OF PHYSICS, BHUBANESWAR
RECEIPTS & PAYMENTS FOR THE FINANCIAL YEAR 2014-15

(Figure in Rs.)

	RECEIPTS	SCH	Current Year	Previous Year		PAYMENTS	SCH	Current Year	Previous Year
I.	**Opening Balance**				I.	**Expenses**			
	a) Cash in hand		16,427	8,770		a) Establishment Expenses	13	11,69,37,494	11,25,75,727
	b) Bank balances					b) Administrative Expenses	14	4,35,84,081	3,75,34,327
	i) In current accounts SBI		37,59,422	3,20,11,693		c) Maintenance Expenses	15	1,74,26,337	1,64,51,172
	ii) In deposit accounts				II.	**Payments made against funds for various projects**			
	LK Panda (SBI Term Deposit)		1,00,000	1,00,000		TPSc		1,07,001	91,204
	iii) Savings accounts					LK panda Scholarship		5,000	5,000
	Indian Overseas Bank (NP)		1,24,96,771	14,25,320					
	Indian Overseas Bank (Plan)		3,01,75,979	18,21,465					
	Union Bank (NP)		6,24,506	1,28,953	III.	**Expenditure on Fixed Assets & Capital W.I.P**			
	Union Bank (Plan)		84,77,010	1,15,449					
	SBI (LK Panda)		45,392	48,478		a) Purchase of Fixed Assets	16	11,36,62,098	4,76,68,590
	Union Bank (TPSC)		12,304	45,977					
II.	**Grants Received**				IV.	Interest Receivable		-	-
	a) From Govt. of India - Plan		9,40,00,000	6,91,83,000					
	Non-Plan		22,00,00,000	17,08,00,000	V.	**Project Revenue Expenses**	17	1,03,60,905	1,00,00,491
	b) From State Government		-	-	VI.	**STAFF LOAN**	18	12,58,708	5,93,466
	c) Raja Ramana Fellowship		-	7,14,153					
III.	**Receipts against Sponsored Projects**				VII.	Security Deposit with CESU		-	-
	TPSC		1,00,000	55,000					
IV.	**Income on Investments from**				IX.	**Closing Balance**			
	LK Panda A/c		1,750	1,914		a) Cash in hand		33,592	16,427
	TPSC A/c		2,255	2,531	X.	b) Bank balances			
V.	**Interest Received**	11	25,60,420	22,38,241		i) In current accounts SBI		1,22,72,793	37,59,422
VI.	**Other Income (Specify)**					ii) In deposit accounts			
	Misc Receipts		4,10,917	878		LK Panda (SBI Term Deposit)		1,00,000	1,00,000
	Sale of Tender paper		34,100	24,800		iii) Savings accounts			
	House/Guest House Rent		10,45,539	10,96,476		Indian Overseas Bank (NP)		1,74,25,370	1,24,96,771
	Advance from NISER		-	-		Indian Overseas Bank (Plan)		3,31,53,164	3,01,75,979
	Sale of Asset		32,500	-		Union Bank (NP)		81,339	6,24,506
VII.	**Other Receipts**					Union Bank (Plan)		75,07,354	84,77,010
	Earnest Money Deposit		1,64,350	6,92,848		SBI (LK Panda)		42,142	45,392
	Security Deposit		(4,78,706)	(2,52,373)		Union Bank (TPSC)		7,558	12,304
	Security Deposit BSNL		-	-					
	Caution Money		1,600	2,000					
	RECOVERY OF STAFF LOAN	12	3,82,400	3,62,215					
	TOTAL		**37,39,64,936**	**28,06,27,788**		**TOTAL**		**37,39,64,936**	**28,06,27,788**

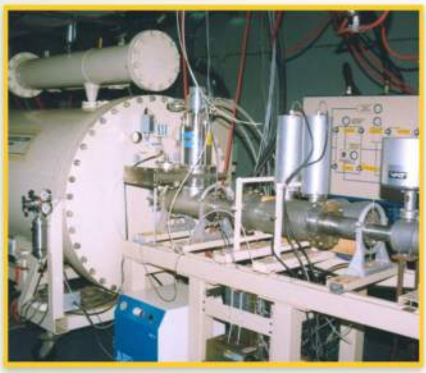
For LAL DASH & CO
Chartered Accountants
(CA A.K. SAMANTARAY FCA)
PARTNER
M.No.053226

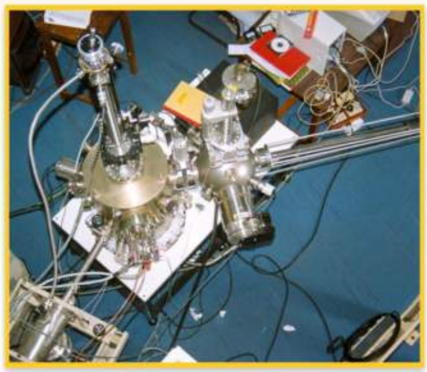
ACCOUNTS OFFICER

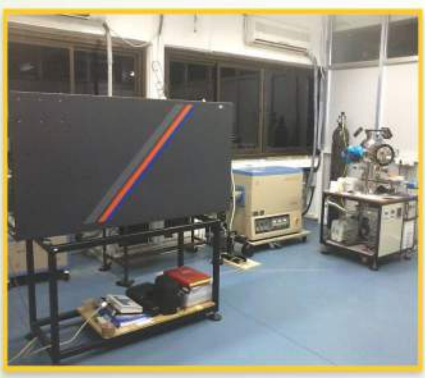
DIRECTOR

NOTES


FEGSEM and FIB





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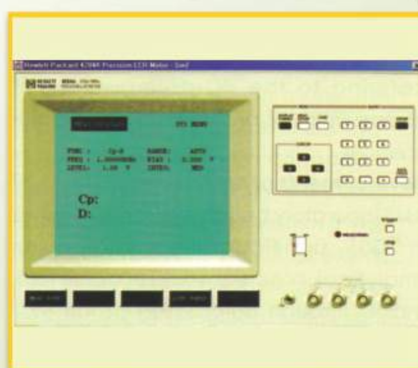
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INSTITUTE OF PHYSICS

P.O. : Sainik School, Sachivalaya Marg,
Bhubaneswar-751005, Orissa, India.
Phone : +91-674 - 2306400 / 444 / 555
Fax : +91-674 - 2300142
URL : http://www.iopb.res.in

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