"We explore the Universe, literally, from the smallest to the largest scales, not just in terms of length but also in energy and time. We spy on exotic particles whizzing inside colliders. We study how a collection of particles behave at low temperatures, normal temperatures, high magnetic fields and other extremes of nature. We venture into the basis of life and evolution, order and chaos. We care about the Sun's magnetic fields and worry about the weather in space. We flirt with black holes and swim in space-time ripples. Yes, we are physicists. Come join us, there is a Universe to fathom..."

Physicists at IISER Kolkata have published in leading international journals such as Nature, Science and Physical Review Letters and they have produced students who are now at the leading institutions of the world such as Cambridge, Cornell, IISc, JNCASR, Maryland, Oxford and Rutgers. They have won awards for their work, both within and outside the country, and their research and interviews have been highlighted in forums as diverse as the Times of India to the New York Times Dot Earth Blogs. Here is the story of this merry bunch of physicists and the Department they nurture.

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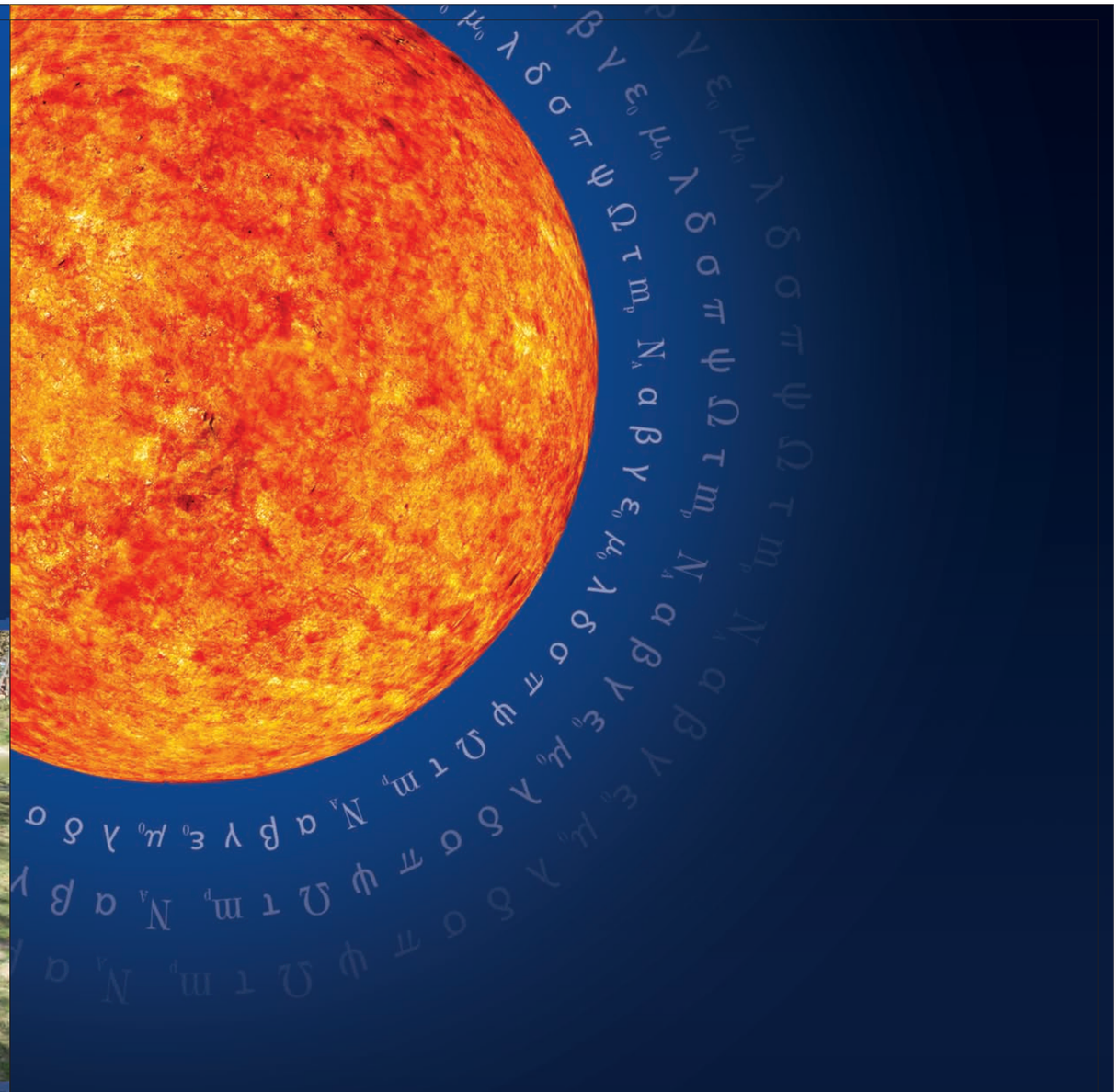
Website (Physical Sciences): http://phys.iiserkol.ac.in/
Website (Institute): http://www.iiserkol.ac.in/



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Department of Physical Sciences

IISER KOLKATA
2013

Indian Institute of Science Education and Research Kolkata

IISER KOLKATA

Department of Physical Sciences 2013

If you want to build a ship, don't drum up people together to collect wood and don't assign them tasks and work, but rather teach them to long for the endless immensity of the sea.

Antoine de Saint-Exupéry

Department Brochure 2013

Department of Physical Sciences

Indian Institute of Science Education and Research Kolkata

Foreword

Despite the long hours, many sleepless nights and numerous cups of tea that were invested on this book, it has been a pleasure putting this together for the Department of Physical Sciences at the Indian Institute of Science Education and Research (IISER), Kolkata. We envisage this book as a window – albeit an abstract one – between the outside world and us. On the one hand, this window allows you – the reader – to peer into our domain and on the other hand, this window provides us with a frame to showcase our creations.

IISERs are new institutes, fledgling but ambitious. We believe that IISERs are possibly the greatest endeavour in Indian science in recent years and we nurture this dream and toil to turn this into reality. This belief is our inspiration for reaching out to the outside world to tell our story.

Our Department is relatively young, but what we have achieved in these few years would be evident to anyone reading this book. If you like our story, share this with others. If you are a student and you are interested in what we do, write to us. If you are a colleague and respect our work, well, it simply takes an extended hand to be a collaborator. So, welcome to our world...

Arindam Kundagrami

Editorial Coordinator, Department of Physical Sciences

Dibyendu Nandi

Editorial Coordinator, IISER Kolkata

Table of Contents

Message from the Director

This book contains academic profiles of faculty members of the Department of Physical Sciences, Indian Institute of Science Education and Research, Kolkata and details of their teaching and research activities.

The Indian Institutes of Science Education and Research (IISERs) were established by the Ministry of Human Resource Development (MHRD), Government of India, based on the recommendation of the Scientific Advisory Council to the Prime Minister. The first two Institutes established under this initiative were IISER Kolkata and IISER Pune in 2006, followed by IISER Mohali in 2007, and IISER Bhopal and IISER Thiruvananthapuram in 2008. Each IISER is an autonomous institution and awards its own degrees. The basic mandate of the IISERs is to provide quality science education and to carry out research in basic and frontier areas of science involving both undergraduate and postgraduate students. Through borderless and flexible education programs, IISERs provide an opportunity for young students to experience the excitements of research in the sciences. In essence, IISERs are devoted to both teaching and research in an integrated manner – thus nurturing both curiosity and creativity.

IISER Kolkata's fully residential campus is coming up on 201 acres of land at Haringhata (Mohanpur). We expect the years 2013-2014 to be exciting and eventful for the growth of IISER Kolkata. The coming years would be an important landmark for us, as the Institute is planning to shift a major part of its activities to the permanent campus.

The first two batches of students who joined in 2006 and 2007 successfully completed their academic requirements for the award of BS-MS dual degree. Notably, about 80% of our first and second-batch BS-MS students, totalling 103, have booked their places in some of the world's best research institutes, including top-notch North American and European Universities, in addition to joining premier research institutes in India. The third batch of students who joined in 2008 is on the verge of completion in May 2013. We are proud of the fact that, as of March 2013, a total of 14 students have completed their PhD research working at IISER Kolkata. We are excited and looking forward to awarding degrees to all three batches of BS-MS students and PhD students during the First Convocation of IISER Kolkata, scheduled in June 2013.

IISER Kolkata offers students a unique educational experience, which is comprehensive in character and rounded in nature. It also offers faculty members and students a modern and flexible environment to grow intellectually through an informal and formal exchange of ideas both within and outside the classrooms. To support continuing growth in interdisciplinary research and teaching, it is understandable that creation of an efficient academic environment is a must. Accordingly, IISER Kolkata strives to train students to become part of this dynamic and evolving scenario. Creating research infrastructure is one of our top-notch priorities. And hence we are continuing to add on to the already existing and impressive experimental facilities.

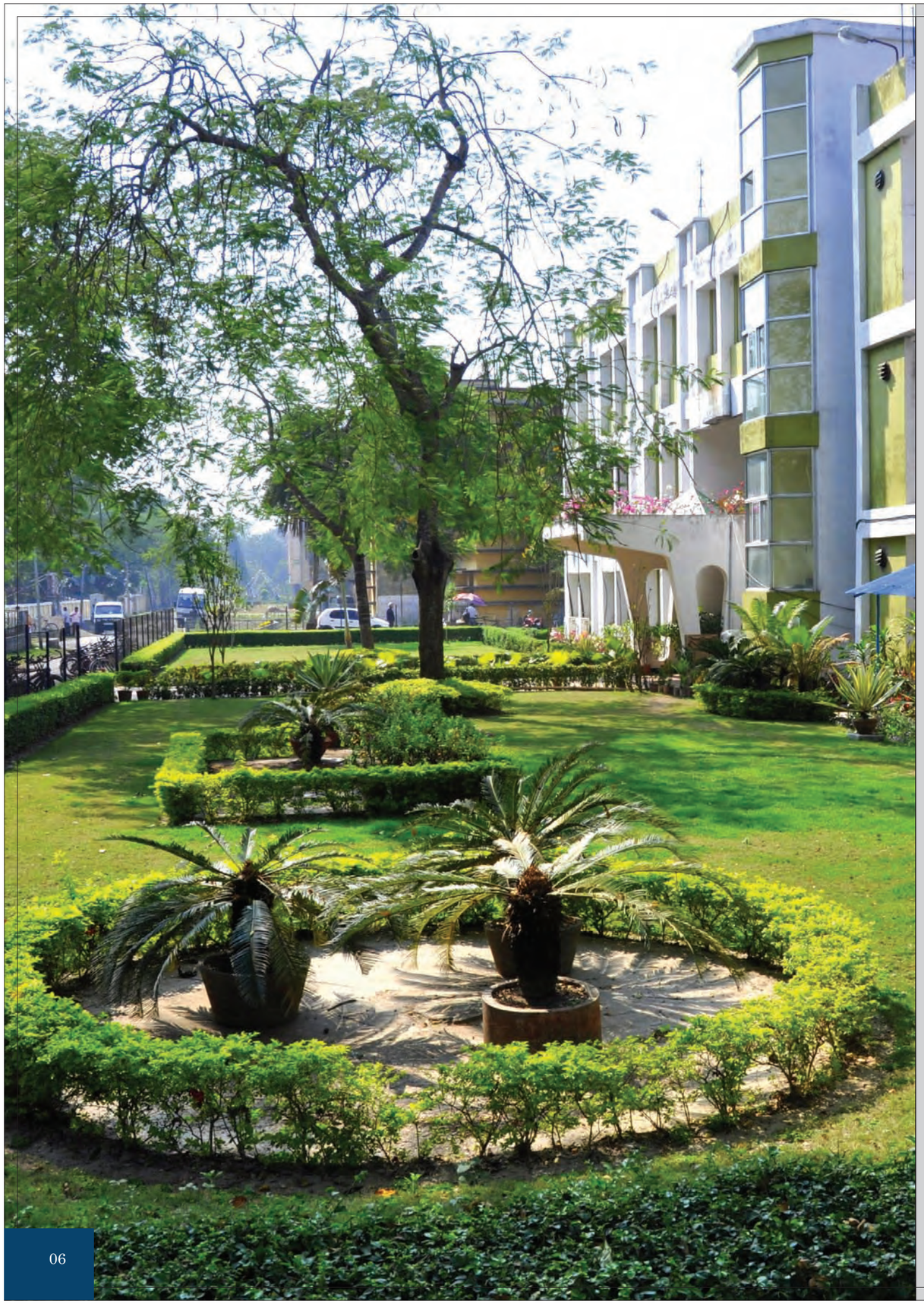
IISER Kolkata has well-trained, committed, and dedicated faculty members to take the Institute to greater heights in the coming years. Our faculty members are supported by attractive start up and matching research grants. With 76 regular faculty, 407 BS-MS students, 57 Integrated PhD students, 177 PhD students, and 2 Post-Doctoral Fellows, IISER Kolkata is vibrant with academic activities. It is a matter of great satisfaction that faculty members have been publishing their research papers in journals of international repute, based on work done at IISER Kolkata. Some of our young faculty members have excelled in research and have been recognized with national and international fellowships and awards. It is very satisfying to put on record that our colleagues have attracted funding through 76 sponsored research projects amounting to about Rs. 32 Crores. Moreover, the academic activities of IISER Kolkata are supported by 53 non-teaching staff members.

Apart from engaging in scientific activities, students and faculty of IISER Kolkata are also involved in various social and outreach activities. We are trying our best to fulfil our social commitment through various outreach programs. The Institute plans to develop a synergetic network with other academic institutions both in India and abroad, addressing fundamental issues related to science education in India.

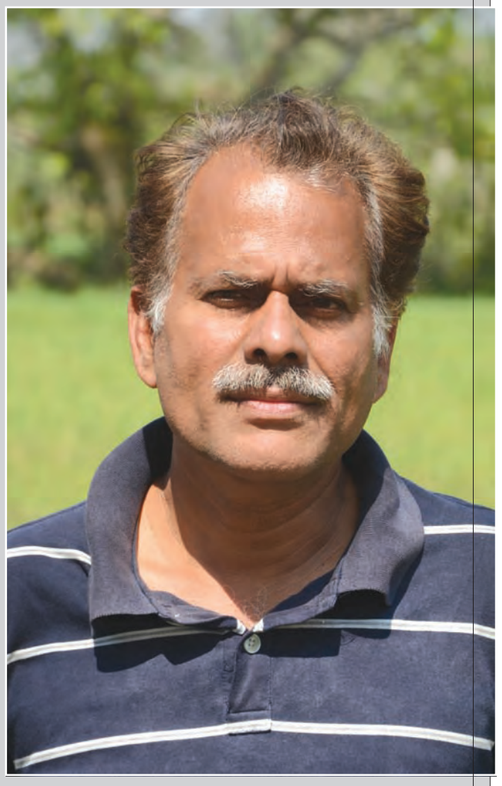
To conclude, for inquisitive young minds looking for a platform to experience a fine blend of quality teaching and world-class research in basic sciences and for young faculty candidates keen to get an opportunity to make a name in teaching and cutting-edge research, IISER Kolkata is one of the best institutions in India to reckon with. As I believe in collective responsibility and team efforts, I find IISER Kolkata is an ideal place to take quality faculty members and students, and non-teaching staff members along with me in this educative and satisfying journey to build, to nurture, and to see the fruits of a budding academic institute of substantial promise. Personally, I am humbled and grateful to be a part of this challenging and exciting environment of IISER Kolkata.

R.N. Mukherjee

Prof. R. N. Mukherjee
Director



Message from the Head of the Department



Prasanta K. Panigrahi

The Department of Physical Sciences (DPS) at IISER Kolkata devotes itself to the study of Physics and its applications towards understanding the world around us. The research areas of specialization broadly include astrophysics and space science, atomic, molecular, and optical physics, biophysics, complex systems, condensed matter physics (including soft matter physics), gravitation and cosmology, high energy physics, mathematical physics, and nonlinear dynamics. The present DPS strength includes 27 faculty, 1 senior scientific officer, and 1 IISER Fellow of whom there are 13 experimentalists, and 16 theorists. The DPS family includes 50 doctoral students (both Integrated PhD and regular PhD), whose strength is being gradually increased keeping in mind the strong commitment of the IISER system towards research with quality teaching. The rigorous teaching program of the department integrates the requirements for the Integrated BS-MS, Integrated PhD and PhD courses that are offered here.

The BS-MS students specialize in physics from 3rd year onwards and subsequently carry out a year-long research project in their fifth year. The IPhD students start research early through a project in their 2nd year as part of their course work. Emphasis on problem solving with the active help of teaching assistants and carrying out research projects in their spare time keep the students engrossed in the academic program. A number of students are authors of high quality research papers published in peer reviewed international journals. The research activities range from the highly specialized to the highly interdisciplinary, in line with the spirit of interdisciplinary research at IISER Kolkata. The doctoral students (both IPhD and PhD) and members of faculty carry out journal club activity, weekly seminars, as well as hosting distinguished visitors from India and abroad. The department regularly conducts national and international workshops and encourages its faculty to participate in academic meets of repute. Departmental faculty have received global recognition for their research and are leading new initiatives such as the Centre for Study of Materials under High Pressure and the MHRD Centre of Excellence in Space Sciences. All of the above give us good reason to eagerly look forward to the exciting times that await. Do join us on this journey.

PEOPLE

Faculty

Ayan Banerjee (Optical Spectroscopy experiments)
Narayan Banerjee (Gravitation & Cosmology theory)
Soumitra Banerjee (Nonliner Dynamics theory)
Bhavtosh Bansal (Condensed Matter experiments)
Rangeet Bhattacharyya (Nuclear Magnetic Resonance)
Ananda Dasgupta (Quantum Phenomena theory)
Amitava Datta (High Energy theory)
Rumi De (Nonlinear Dynamics &Biophysics theory)
Amit Ghosal (Condensed Matter theory)
Anandamohan Ghosh (Nonlinear Dynamics & Biophysics theory)
Nirmalya Ghosh (Optics, Spectroscopy, & Biophotonics experiments)
Golam Mortuza Hossain (Gravitation & Cosmology theory)
Arindam Kundagrami (Soft Condensed Matter theory)
Siddhartha Lal (Quantum Condensed Matter theory)
Chiranjib Mitra (Quantum Condensed Matter)
Partha Mitra (Condensed Matter experiments)
Goutam Dev Mukherjee (Condensed Matter experiments)
Dhananjay Nandi (Molecular Dynamics experiments)
Dibyendu Nandi (Astrophysical Space Sciences)
Rajesh Kumble Nayak (Astrophysics & Gravitation)
Bipul Pal (Ultrafast Spectroscopy in Semiconductor experiments)
Prasanta Panigrahi (Field theory)
Satyabrata Raj (Condensed Matter experiments)
Supratim Sengupta (Complex Systems & Biophysics theory)
Ritesh Singh (High Energy theory)
Subhasis Sinha (Condensed Matter theory)
Prashanth Upadhya (Condensed Matter experiments)

IISER Fellows

Pradip Khatua (Condensed Matter experiments)

Senior Scientific Officers

Uday Kumar (Condensed Matter experiments)

Staff

Indrajit Chatterjee
Scientific Officer (indra.chatterjee)
Physics Laboratories

Pintu Das
Laboratory Assistant and Department Secretary (pintudas)
Mechanical Workshop

Subhash Malo
Attendant (subhas.malo)
Physics/Electronics Laboratory

Rajni Marrick
Scientific/Technical Assistant (rajni)
Physics/Electronics Laboratory

Gour Gopal Paul
Lab Technician (gour.gopalpal)
Physics Laboratories

Ananda Mohan Saha
Attendant (anandasaha)
Physics/Electronics Laboratory

We gratefully acknowledge the support of the staff of the Administration & the Computer Section.

PhD (RS) Students of DPS (37)
Integrated PhD students of DPS (15)
MS students of DPS (65)

Webpages:
Faculty:
http://phys.iiserkol.ac.in/faculties.html
Staff:
http://phys.iiserkol.ac.in/staff.html
Students:
http://phys.iiserkol.ac.in/students.html

ACADEMIC PROGRAMMES

INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH KOLKATA was established in 2006 by the Ministry of Human Resource Development (MHRD), Government of India. IISER Kolkata is an autonomous institution awarding its own degrees. Department of Physical Sciences (DPS) in IISER Kolkata offers four academic programmes with varying degree of emphasis on teaching and research as follows.

Integrated Dual-degree BS-MS Programme

[Current student strength: 410 (Institute), 65 (Physics)]

This remains the flagship teaching programme of DPS. Students are admitted through institute level procedures (see below) after their higher secondary level schooling.

ADMISSIONS: Students must qualify in one of the following examinations for consideration for admission. The programme starts in August.

Kishore Vaigyanik Protsahan Yojana (KVPY) Fellowship: KVPY is one of the most prestigious fellowships for students who have completed their secondary level schooling. The fellowship is offered by the Department of Science and Technology (DST), Govt. of India, to candidates with exceptional aptitude in science, after a written exam and an interview (Web: www.iisc.ernet.in/kvpy).

National Olympiads: The Olympiad examinations, the science equivalent of the International Olympics, are conducted at regional, national and international levels, and are considered to be the toughest and the most challenging exams at the pre-college level. Participation in the National Olympiad Camp remains rare honor, and students representing India in the International Olympiads are eligible for applying.

IIT-JEE: The students qualifying the IIT-JEE are eligible to apply for admission in IISER-K. (Web: www.jee.iitk.ac.in and other IIT websites).

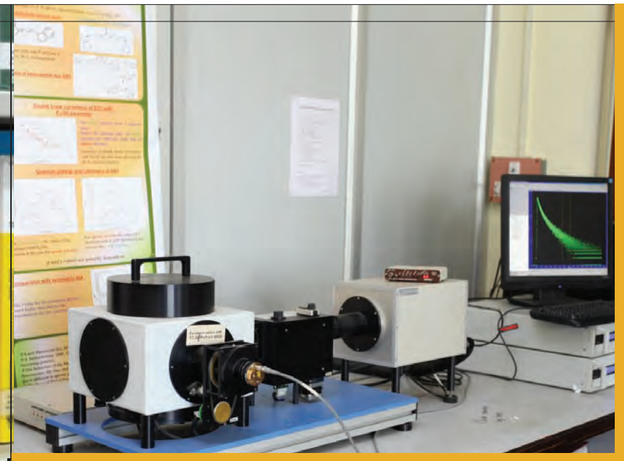
State & National Board exams: Students who stand among the top layer (currently top 1% - as per DST or board cut-off tables) of their respective boards in higher secondary or equivalent exams, may apply to appear in an IISER aptitude test, qualifying which they are offered admission. (Web:http://www.iiser-admissions.in/)

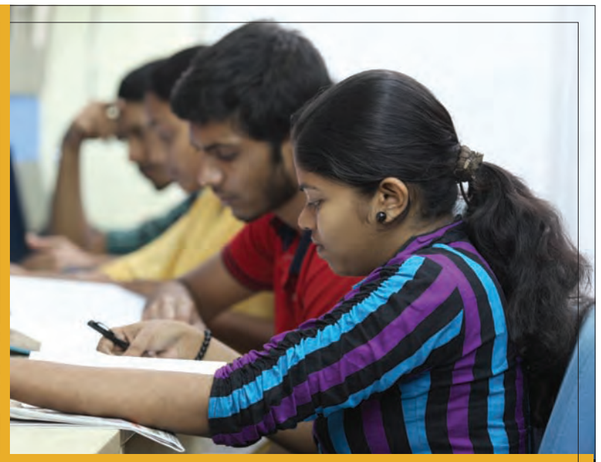
Students admitted in the BS-MS programme in IISER Kolkata are automatically eligible for the INSPIRE fellowship awarded by DST.

Integrated Ph.D Programme

[Current student strength: 62 (Institute), 15 (Physics)]

This is our flagship research programme. Students are admitted through a department level selection procedure





comprising of screening, a written test, followed by a thorough interview. This is a PhD programme in Physics in which outstanding undergraduates (after B.Sc. or B.Tech.) are drafted early, and then go through a rigorous and specialized coursework for two years before they start their research in the frontiers in physics. The programme starts in August.

PhD Programme

[Current student strength: 158 (Institute), 37 (Physics)]

This is our regular Ph.D programme in which bright and motivated Physics graduates are admitted (after M.Sc) through a department level selection procedure comprising of screening followed by a rigorous interview.

ADMISSIONS (for both IPhD and PhD):

The advertisements for IPhD & PhD programmes appear in the Institute website in March-April. The written test and interviews are taken sometime between May-July.

(Web: http://www.iiserkol.ac.in/academics/programmes/)

Students admitted in the IPhD programme in Physics in IISER Kolkata are awared a healthy stipend by the institute in their first two years before they are elevated to the scale of regular PhD students (CSIR-UGC JRF).

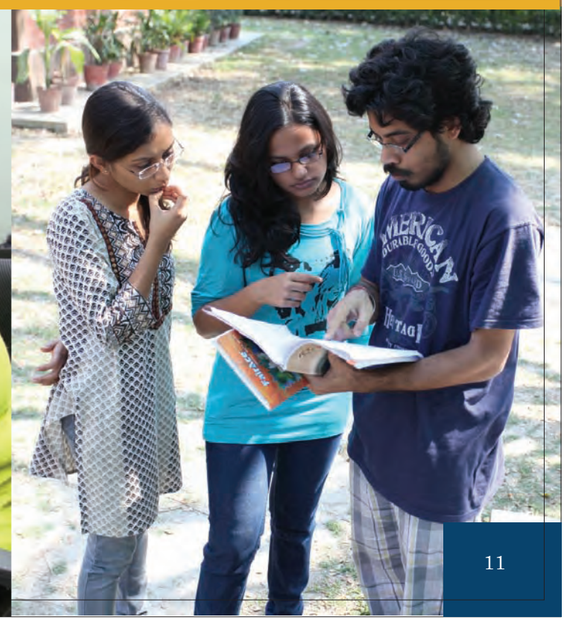
Postdoctoral Programme

A few PhDs with outstanding academic records are hired as postdoctoral fellows in DPS every year. The fellows are expected to collaborate with the DPS faculty on challenging problems in physics and related disciplines.

HIRING: Postdoctoral fellows are hired through DPS advertisements (in the Institute website) anytime during the year. The screened candidates may be invited to present his work in person or through web which will constitute the candidate's interview.

(Web:http://www.iiserkol.ac.in/academics/programmes/)

PhDs hired in the Postdoctoral programme in Physics in IISER Kolkata will receive stipend and benefits commensurate with Government of India regulations.



RESEARCH & FACILITIES

Research Activities

We explore the Universe, literally, from the smallest to the largest scales, not just in terms of length but also in energy and time. We spy on exotic particles whizzing inside colliders. We worry about how a collection of particles behave at extreme temperatures, pressures and magnetic fields. We try to understand the basis of life and evolution, order and chaos. We flirt with black holes and swim in space-time ripples. We care about the fact that the Sun has magnetic fields and worry about the weather in space. Our research portfolio encompasses almost all major areas of physics, areas whose boundaries we try to stretch every day, working with our minds, pen, paper, computers and instruments mixed with a healthy dose of romance for our subject.

Theoretical Physics

Understanding the origin, dynamics, large-scale structure and fate of the Universe requires delving into the fields of gravitation, cosmology and general relativity. Dr. Rajesh Kumble Nayak works on testing theories of gravity and is involved in the hunt for gravitation waves. He also investigates the properties of the Black Holes in non-flat backgrounds. Dr. Narayan Banerjee's current interests are focussed on Dark Energy, which is believed to be the driver of the accelerated expansion of the Universe. While, general relativity is an amazingly successful theory of gravitation, it predicts the existence of singularities in regions of extreme densities where it is thought to become unreliable. It is believed that a suitable reconciliation of general relativity with quantum theory, another tenet of modern physics, is needed to address this issue. Dr. Golam Mortuza Hussain is involved in the quest for a quantum theory of gravity which is expected to supersede general relativity in describing physics near extreme gravitational situations. In particular his research is focussed on loop quantum cosmology (LQC) and loop quantum gravity (LQG).

Closing in on our immediate neighbourhood, the most dynamically active astrophysical object in the solar system is our parent star – the Sun. The energy and particulate output of the Sun varies, primary driven by its magnetic fields. On the one hand, the slow long-term variation of solar output is relevant for planetary climates such as that of the Earth's, especially in the context of global climate change. On the other hand, transient, energetic events such as solar storms create hazardous space weather that impacts Space and Earth-based technologies. Dr. Dibyendu Nandi uses theoretical and computational approaches and data from satellites to explore the origin and impact of the Sun's activity on our Space environment. In particular, he is interested in developing physics-based models for space weather forecasting.

At the smallest lengthscales in nature, we are confronted with fundamental questions regarding its building blocks, i.e., matter and radiation. Particle physics seeks to answer those questions at the theoretical level, and at the experimental level, hunt for exotic particles that are keys to understanding the world. Dr. Amitava Datta and Dr. Ritesh K. Singh are engaged in assessing the prospect of discovering physics beyond the standard model of particle physics at the Large Hadron Collider (LHC). Dr. Datta has used the existing LHC data to constrain new physics models like supersymmetry. Dr. Ritesh Singh is interested in measurement of Charge-Parity (CP) violation and top quark polarization at the LHC. He is also involved in studying the physics potentials of the proposed International Linear Collider.

Condensed matter physics takes the route of emergence in exploring the universe: here, a system is always more than just the sum of its parts. The enormous diversity in our physical world that ranges from the atom to the planet is testimony to the power of emergent phenomena. In keeping with this, the condensed matter theory group at DPS works on areas as diverse as self-assembly of soft matter and high-temperature superconductivity. For instance, Dr. Subhasis Sinha probes the many ways that lead from a superconducting state of Cooper pairs to a Bose-Einstein condensate. Dr. Amit Ghosal, on the other hand, explores how quantum fluctuations can melt a correlated state of electrons (the Wigner molecule) formed in a quantum dot. Dr.Arindam Kundagrami investigates the equilibrium and dynamics of classical systems ranging from liquid crystals to charged polymers in aqueous background. Can one transport electrons from a quantum dot in a sheet of graphene into a superconductor, wonders Dr. Siddhartha Lal? Dr. Prasanta K. Panigrahi studies the dynamics of topological excitations in Bose-Einstein condensates, cold fermions and many body physics.

These studies use knowledge gleaned from the full spectrum of physical sciences and are highly relevant for understanding the world of materials sciences and driving emerging technologies.

The research of the members of the nonlinear dynamics and biophysics group ranges from pure dynamical systems to various problems in biological physics spanning systems from the genome to cells and tissues to complete organisms. Dr. Supratim Sengupta explores what kind of building blocks is necessary for sustaining life? He also seeks to understand how individual human behavioural impulses lead to the emergence of cooperative social dynamics. Dr. Anandamohan Ghosh uses tools of statistical physics and dynamical systems to understand important issues in biophysics such as how cells regulate gene expression in the presence of noise and how a group of neurons respond coherently to some sensory stimuli. Dr. Rumi De investigates how cells and tissues respond to mechanical forces and the dynamics of cells in response to environmental cues. These are some of the interesting questions in the biological context that motivate the biophysics

group. These problems are tackled using tools and methods developed in mathematical physics, statistical physics, elasticity, soft condensed matter theory, evolutionary game theory and bioinformatics.

In the context of dynamical systems, understanding how coupled phase oscillators show peculiar behaviour like quasi-periodicity and chaos is also a focus of this group. In particular, Dr. Soumitro Banerjee analyzes non-linear dynamical systems such as switching electronic circuits and their special behaviours such as bifurcations.

Much of our understanding of the physical world depends on mathematics, on theoretical constructions that perhaps sometimes appear abstract, but which are immensely useful in understanding the vagaries of nature. In keeping with this, Dr. Ananda Dasgupta is interested in Lie-algebraic techniques in the field of quantum optics, especially in squeezed states and matter radiation interaction, and also on fundamentals of quantum and statistical mechanics.

Dr. Prasanta K. Panigrahi works on non-commutative field theory, quantum computation, and applications of wavelet transforms.

Should theorists worry about data, especially large volumes of data? Our answer to that question is an absolute yes! There is an emerging thought amongst scientists that making sense of large volumes of data will drive our scientific breakthroughs in the coming century. Whether this be hunting for gravitational waves, or for exotic particles in colliders, creating algorithms for satellite data-based space weather predictions, looking for trends in global and regional climate, or mining the genomic database – the power of intelligent data analysis and modelling is here to stay. Dr. Rajesh Kumble Nayak, Dr. Dibyendu Nandi and Dr. Prasanta K. Panigrahi are all involved in large volume data analysis. This activity encompasses creation of new statistical and wavelet based data mining tools and development of data modelling techniques with the aim of constraining theories and to glean out mysteries of nature buried in data.

Experimental Physics

Experiments provide the foundation on which the theoreticians build their models. Therefore, the Department aims to establish a set of state-of-the-art experimental facilities which can broadly be classified into two nearly equally populated segments, namely, experimental condensed matter group, the optics and spectroscopy group.

The experimental condensed matter group is primarily interested in studying manifestation of quantum effects in matter under extreme experimental conditions such as low temperatures, high magnetic fields, high pressures, reduced dimensions or combinations of these. The group boasts of one of the finest experimental facilities in the country capable of studying a wide range of materials of current interest like topological insulators, multiferroics, diluted magnetic semiconductors, organic semiconductors, manganites, high-Tc superconductors and semiconductor quantum dots and wells. The magnetism group led by Dr. Chiranjib Mitra aims to understand the fundamentals of quantum magnetism and possible application in quantum computing using sensitive magnetometry and magneto-optical techniques. The spintronics group led by Dr. Partha Mitra focuses on possible mechanisms to generate, detect and manipulate spin polarized currents in semiconductors. The high pressure physics lab led by Dr. Goutam Dev Mukherjee seeks to simulate conditions of various geological processes with the aim of understanding the fundamentals of phase transitions under these conditions. Dr. Satyabrata Raj is an expert on the technique of angle resolved photoemission spectroscopy (ARPES) which is an indispensible tool for determination of electronic structures of materials. The high magnetic field group led by Dr. Bhavtosh Bansal has indigenously developed a pulsed magnet facility that is currently being used to study exotic effects in semiconductors. Dr. Prashanth C. Upadhya specializes in Terahertz spectroscopy, and the use of ultra-fast spectroscopy techniques to probe the physics of lower dimensional structures.

The optics and spectroscopy group is involved in many interesting and intriguing research activities probing the diverse aspects of light itself as well as light matter interactions at different spatial and temporal scales. The Semiconductor Spectroscopy Group led by Dr. Bipul Pal and Dr. Bhavtosh Bansal is interested in understanding the basics of light-matter interaction in novel semiconductor nanostructures using steady-state and femtosecond

time-resolved spectroscopy at low temperatures. The optical micromanipulation lab set up by Dr. Ayan Banerjee uses optical tweezers to confine mesoscopic particles ranging from nano-particles to biological cells and perform diverse experiments to reveal fundamental properties of the particles as well as that of the light used for trapping. Dr. Nirmalya Ghosh has set up a bio-optics and nano-photonics lab (BioNap) where the main emphasis is on understanding the light-matter interaction by exciting localized surface plasmon resonances in metal nano-structures or morphology dependent resonances (whispering gallery modes) of microscopic dielectric structures, as well as using various optical spectroscopic approaches (elastic scattering, fluorescence, Raman) for probing biological and other complex systems. Dr Dhananjay Nandi studies various interesting experiments with generation of supersonic molecular beams to create cold molecules and clusters towards understanding the quantum mechanics of gas phase molecular reactions using indigenously developed novel techniques. Dr Rangeet Bhattacharya's interests are in developing novel experimental techniques in solid and liquid state Nuclear Magnetic Resonance (NMR) with the goal of studying dynamics of liquid molecules and solids, thus exploring phenomena such as the nonlinear effects of excitation schemes on the spin dynamics or the nature of quantum decoherence in various entangled states.

Research Areas

Astrophysics and Space Sciences
Solar and stellar magnetism
Magnetohydrodynamic dynamo theory
Space weather predictions
Space mission support and satellite data analysis

Biophysics and Complex Systems
Evolutionary game theory
Dynamics of social cooperation
Gene expression
Computational neuroscience
Biophotonics
Biopolymers
Bioinformatics
Mechanobiology

Condensed Matter Physics
Semiconductor nanostructures
Physics in high magnetic fields
Nuclear Magnetic Resonance
Giant Magnetoresistance
High temperature superconductivity
Strongly correlated systems
Low-dimensional quantum systems
Quantum computation and information processing
Spintronics
Nanotechnology
Physics at high pressure
Physics at high magnetic fields and low temperatures
Many body physics
Bose-Einstein condensates
Quantum phase transitions
Atomic force microscopy

Data Analysis and Computation
Statistical and wavelet techniques
Algorithm development
Data modelling
Global climate reconstruction and trends
Satellite data analysis
Ground-based observatory data analysis

Gravitation and Cosmology
Physics of Black Holes
Gravitational waves
Quantum gravity
Quantum cosmology
General theory of relativity

Mathematical Physics
Lie-algebraic techniques in quantum optics
Foundations of quantum and statistical mechanics
Group theory
Non-commutative field theory

Non-Linear Dynamics
Dynamical systems
Quasi periodicity and chaos

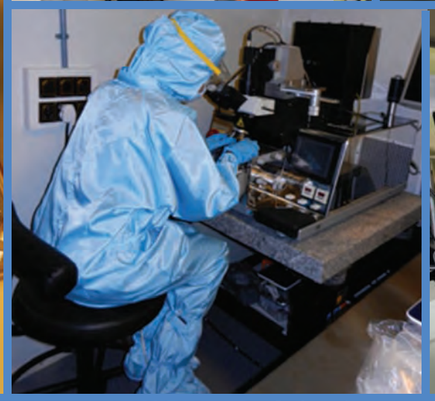
Optics and Spectroscopy
Precision optical spectroscopy
Ultrafast spectroscopy
Photoemission spectroscopy
Nanophotonics

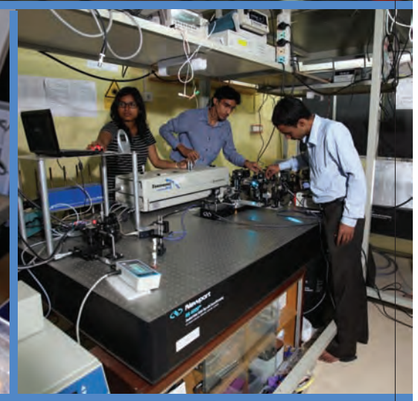
Particle Physics and High Energy Physics
Collider phenomenology
Super-symmetry

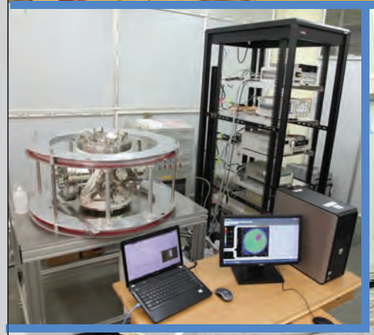
Soft Matter Physics
Physics of liquid crystals, colloids, & polymers
Diffusive systems

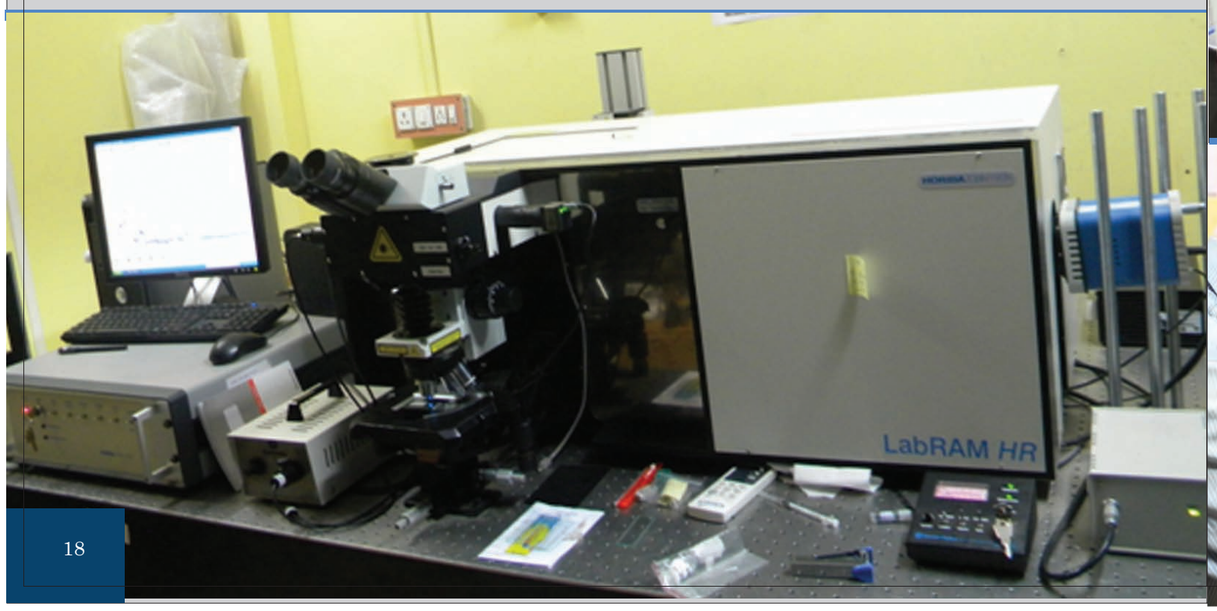
Experimental Facilities

Magnetic Properties Measurement System (MPMS) (Chiranjib Mitra, Partha Mitra)
Cryogen-free Transport Properties Measurement System (Chiranjib Mitra, Partha Mitra)
Magneto Optic Kerr Effect (MOKE) measurement setup (Chiranjib Mitra)
Class-100 clean room (Partha Mitra)
Mask Aligner for photolithography (Partha Mitra)
Spin Process Station (Partha Mitra)
Profilometer (Partha Mitra)
Thin film workstation (Partha Mitra)
Atomic Force Microscope (AFM) (Partha Mitra)
Field Emission Scanning Electron Microscope (FESEM) and e-beam lithography (Partha Mitra)
Pulsed Laser Deposition System (Chiranjib Mitra)
Micro-Raman measurement facility (Goutam Dev Mukherjee)
High Temperature Arc Melting Furnace (Satyabrata Raj)
High field pulsed magnet facility (Bhavtosh Bansal, Pradip Khatua)
Semiconductor spectroscopy facility (Bipul Pal, Bhavtosh Bansal)
Optical micro manipulation Lab (Ayan Banerjee)
Multimodal spectroscopic imaging system (Nirmalya Ghosh)
Tunable wavelength ultrafast laser spectroscopy facility (Prashanth C Upadhya)
Velocity Map Imaging spectrometer (Dhananjay Nandi)
Nuclear Magnetic Resonance (NMR) spectrometer (Rangeet Bhattacharya)
Mechanical Workshop (Satyabrata Raj, Pintu Das (Technician))
i) All geared Bench lathe Machine ii) Heavy Duty Universal Milling Machine iii) Heavy Duty High Precession Pillar Drill Machine iv) Heavy Duty hydraulic Metal Cutting Hacksaw Machine v) Bench Grinding Machine









Computational Facilities in DPS

High performance computation is the part of modern physics research. Members of the physics department are actively taking part in developing state of the art computational facility in the institute. Presently, the department has a few high-end workstations and a couple of small clusters. Smaller clusters are mainly used for developing parallel codes, training students, and to run small simulations. We have a cluster *Meghnad* which is developed by putting together teaching lab desktops. It has nearly 40 nodes and can be used for low memory but high CPU jobs.

In addition to the hardware, softwares such as Mathematica, Matlab, and Labview are available for both research and teaching labs.

GPU based computation is considered as the future of high-performance computing. In addition to standard CPU based workstations, our department is also exploring possibilities for GPU based systems for cost effective high-end computing. Some of the currently available systems are being used for developing efficient codes for running on GPU based systems to explore future GPU based high-end computing.

National Knowledge Network

The National Knowledge Commission under the Government of India has initiated an effort to inter-connect all institutions of higher learning in the country. As a part of this effort, IISER Kolkata has been connected to National Knowledge Network (NKN) through optical fibre link since July 2011. This connectivity has become the core internet link of IISER Kolkata to the world at large. The provisioned bandwidth of this link is 100 Mbps at present.

Virtual Classroom at IISER Kolkata: As an application to use the high-speed connection provided through National Knowledge Network, a Virtual Classroom has been set up at IISER Kolkata. This Virtual Classroom facility is meant to bridge the physical distance between teachers and students who are at different physical locations. For example, students at IISER Kolkata can attend a class that is being held at IISER Pune and ask live questions (picture below) to the teacher there and vice-versa. The Virtual Classroom facility, which is capable of transmitting and receiving interactive high-definition video classes across the globe through internet, was inaugurated on 16th February 2012 at IISER Kolkata by Prof. R. N. Mukherjee, the Director of the institute.

Library

The IISER Kolkata Library is fast moving towards becoming an important science library in the country. Started in 2006 as one of its first centres, it has become an important information resource centre for the whole institute. The rich and valuable collection built through these years has many important reference materials as well as archival volumes of several important journals. Apart from its print collection, the Library also subscribes to thousands of e-journals, e-books, and several databases. The focus of the Library is to act as the backbone of the information support system of the whole Institute.

Presently, the Library has a collection of around 16,000 print documents, more than 12,000 e-books. It subscribes around 2,300 online and few print journals. The Library has a sizable collection of audio-visual materials to support the teaching and research activities of the Institute. It also has an important collection on Indian heritage in Science, Technology, Arts and Literature. One of the remarkable aspects of our print collection is the books from several renowned series published by some of the best publishers around the world. Apart from the current subscription of journals from eminent publishers like American Chemical Society (ACS), American Mathematical Society (AMS), American Physical Society (APS), Cambridge University Press (CUP), Elsevier, Nature Publishing Group (NPG), Oxford University Press (OUP), Royal Society of Chemistry (RSC), Springer, Taylor and Francis, Wiley, World Scientific etc., the Library had already purchased several important journal archives from many of these publishers on Biological Sciences, Chemical Sciences, Earth Sciences, Mathematical Sciences and Physical Sciences. As a core member of INDEST Consortium, the Library has played a very active role in obtaining several important online resources from it as well. Apart from subscribing to various full-text databases like Annual Reviews, OpticsInfobase, JSTOR, IEEE Electronic Library, ACM Digital Library, the Library also subscribes to several important bibliographic databases like Faculty of 1000, MathSciNet, Project Muse, SciFinder, SCOPUS etc. Recently it has also started to subscribe to the Web of Science database.

To help its users to search and locate the documents, the Library has procured the Virtual Library Management System from VTLS, Inc. USA. The online Public Access Catalogue (OPAC) is available on the Internet <http://lib.iiserkol.ac.in:8000/cgi-bin/gw/chameleon/>. Anyone can search, locate, and identify print documents available using this OPAC. In addition, bona fide users of IISER Kolkata can place reservation and renew books online using this portal. Wi-Fi facility is available inside the Library. The Library also extends the VPN facility to faculty level users to access its subscribed online resources from anywhere. Interested users from other academic Institutions are welcome to use it as a reference library.

Library Hours:
IISER-K Library, Mohanpur Campus
Weekdays: 9.00 to 23.00 hrs.
Saturdays and Sundays: 10.00 to 23.00 hrs.
IISER-K Library, Main Campus
Weekdays: 9:00 to 17:00 hrs.

TEACHING

"Quand tu veux construire un bateau, ne commence pas par rassembler du bois, couper des planches et distribuer du travail, mais reveille au sein des hommes le desir de la mer grande et large.

If you want to build a ship, don't drum up people together to collect wood and don't assign them tasks and work, but rather teach them to long for the endless immensity of the sea."

—Antoine de Saint-Exupéry

In the physics department of IISER Kolkata, we have undertaken the task of teaching our students to long for the immensity of our sea – the vast and wonderful realm of science in general and physics in particular. In addition our aim is to ensure that, when our students graduate, they have in their arsenal the theoretical and experimental tools that will enable them to become successful researchers as well as teachers in their own right. It is also our endeavour to expose our students to the best of current research, in physics as well as related interdisciplinary fields.

Teaching Programme

The IISER system evolved out of a concerted attempt at improving the state of higher education in India. It had been felt for a long time that despite the presence of extremely talented students and faculty, the higher education and research sectors of our country were languishing behind other developed and emerging nations. One reason behind this was felt to be the disconnect between textbook studies and active research, with the traditional universities primarily catering to the former and specialized research institutions focussing on the latter. The need of the hour, it was realized, is to create new institutions that will treat teaching and research on the same footing – and will expose the students to the world of research as an integral part of their study right from the very beginning. So the IISERs were born.

The BS-MS programme

IISER Kolkata began its journey in the August of 2006 with thirty-eight students in its flagship teaching program. This is what is today called the five year integrated BS-MS dual degree program. Since then, we have had two batches of students who have passed out with one more batch almost ready to venture out into the world.

One prevalent trait in current educational methods which is proving counterproductive in today's research scenario is the compartmentalization of science into rigid boundaries of separate disciplines. It is a guiding principle in the IISERs that these boundaries should be dispensed with to the extent possible. At the same time, a balance has to be drawn between too wide a curriculum that will teach a little bit of everything and a restricted curriculum which will allow the students to master some essential topics. With these aims in mind, students study all of the major science streams (Biology, Chemistry, Earth Sciences, Mathematics and Physics) in the first year of the BS-MS course, all at the same level. In addition to the regular theoretical and experimental courses in these major subjects the students are also exposed to a year long course on the applications of computer methods in science. In the second year, the student is expected to choose three of these subjects as pre-majors, and from these he must choose his major subject in the third year. Even after he has chosen a major, a student is required to take minor courses from other subjects in which he has the necessary pre-requisites. In the fourth year and above, the student can take a few inter-disciplinary courses that will broaden his scientific base over and above the core and elective courses from her chosen discipline. Our experience so far has been that this exposure to other subjects has been really beneficial to the growth of a student, both as a scientist and as a person. Moreover, exposure to computer usage and advanced mathematics proves highly helpful for the students in the course of their studies in physics.

Physics is above all an experimental subject. Keeping this in mind, we at IISER Kolkata have developed a mixture of traditional and innovative experiments whose aim is to both impart essential laboratory skills and challenge the students' intellectual curiosity. In advanced classes students get an opportunity to work directly in research labs where they get a feel for real life research.

In the final year of the course a student has to carry out a year long project which is the perfect launching pad for a future research career. Indeed, a student can get exposed to real life research even earlier by choosing to do projects either within IISER Kolkata or elsewhere during the summer break. Here in the physics department we have had several students who had published their work in reputed journals even before completing their coursework. The students also have the option of joining a fast-track research program from their fifth year itself – which will lead to a comparatively early PhD.

We in the physics department take great pride in the fact that our outgoing students have fared very well in the national scale. From our very first batch one student won the coveted Rhodes Fellowship - and what's more, he was the only one from the sciences to win it that year

from India. On the national front, several of our students have qualified in the NET examination. In addition, two of our students have won the prestigious “Shyamaprasad Mukherjee fellowship”. Our students have, by and large, continued to do research in physics both within India and abroad.

The Integrated PhD programme

PhD students are the backbone of research in an institution. In the last twenty years renowned science departments in India have seen unprecedented success in the post-bachelors Integrated PhD programme which produced world-class PhD graduates, a majority of whom are now, in the capacity of faculty, part of the so-called “second wave of science” in IISERs, NISER, and other institutes in India. Keeping in line with this success story, IISER Kolkata has initiated the Integrated PhD (IPhD) programme in the year 2009 for students completing their bachelors in science and engineering. The aim of this endeavour is to attract outstanding and innovative undergraduates to research in basic sciences, and to motivate them to begin cutting-edge research at an early stage of their higher studies.

In the Physics department, we consider our IPhD program as our flagship research program, and we have devised a specialized course work that will best prepare the students to pursue doctoral research in our department. Maintaining the fundamental spirit of an interdisciplinary approach of IISERs, the IPhD students in physics are given more freedom in their choice of courses. Despite giving options for a reasonable exposure to different aspects of basic sciences, the IPhD program emphasizes early focus on major topics in physics. In their 1st year, the IPhD students take, along with 3rd year MS students, 5 core courses each semester. For the additional two electives each semester, however, they are allowed to take physics courses at various levels based on their diverse background. In the 2nd year too, there are specialized courses carefully designed to IPhD students who would begin their research work simultaneously. At this level itself, they start their curriculum project consisting of challenging (and possibly long-term) problems which, in most likelihood, would from the basis of their doctoral work. A departmental advisory committee actively counsels the students to choose elective courses, and encourages them to interact with faculty members to gain a broad perspective on research in different areas in physics. Although IPhD students get to take less number of electives than MS students in their first two years, they are allowed to exchange a few credits between the project and the elective courses. In addition, they can always make it up in their later years of stay as the doctoral student, preferably choosing electives suitable to their ongoing research interest and beyond. During the later part of the IPhD course work a comprehensive test ensures the student's worthiness to continue the doctoral work.

The research project, in conjunction with the specially designed courses suitable for a doctoral programme, brings the IPhD students quickly but steadily to a level where they can be confident of carrying out research on their own. Direct and dedicated contact to a competitive research environment is the key in preparing them for the world of research and eventually launching them towards a world-class doctoral work. Therefore, it is expected that IPhD students would complete their PhD earlier than conventional PhD students. However, we strongly feel that the quality of a PhD is more important than its duration. The rigorous course work we have in place for IPhD students assures a very conducive environment for the students to pursue a well-rounded doctoral degree of high quality. The IPhD program in DPS is in its nascent stage, but gaining momentum in leaps and bounds, and we are confident it will soon deliver excellent results similar to other renowned physics departments in India.

The Institute invites applications for IPhD programme in the fields of Biological, Chemical, Mathematical, Physical and Earth Sciences. In Physics we invite applications from students who have completed a Bachelors degree in physics or engineering from any recognised university. The deserving candidates are selected from the pool of applicants first by a screening based on their academic background, then a rigorous aptitude test, and finally a thorough interview. The selection is in place once a year (advertised tentatively in March). The selected candidates are offered a healthy monthly stipend commensurate with their academic level. Once the students become JRF, their stipend and benefits are raised to the CSIR-NET level.

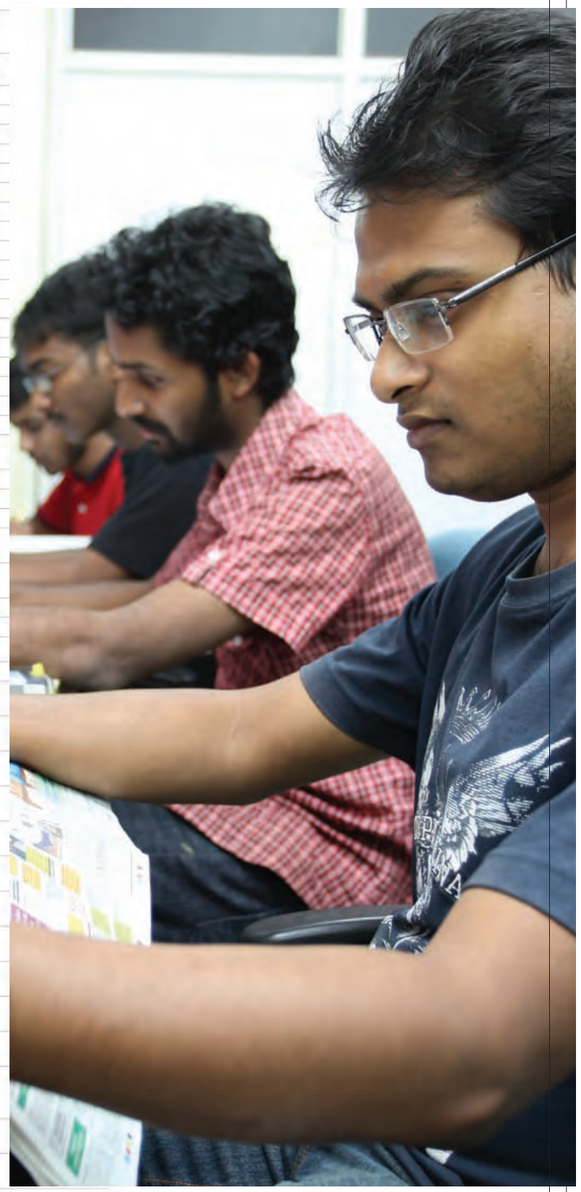
The PhD Programme

The traditional regular PhD programme, like many other leading institutes in India, is also a stronghold in our department to admit and train brilliant graduates (after their Masters) to pursue doctoral research. As we have emphasised before, the IISERs are institutes where research and teaching happen with equal emphasis and passion. This is highlighted by our thriving PhD program where we aim to equal the best in the world. Although the regular PhD students go through a mandatory course work relatively shorter than IPhDs, the syllabus still provides rigour and ample opportunity to a willing student to best prepare for top-flight research. The PhD students have a full one year course work comprising of four courses from levels 3 to 5. The department counsels the students, much in the same way as the IPhDs, in their course choices to help them reap the maximum synergistic benefit from their research and course work.

We admit PhD students twice a year through a process of screening, based on their academic background, followed by a rigorous interview. Exceptional students can be drafted out of turn through a rolling selection process (screening and interview).

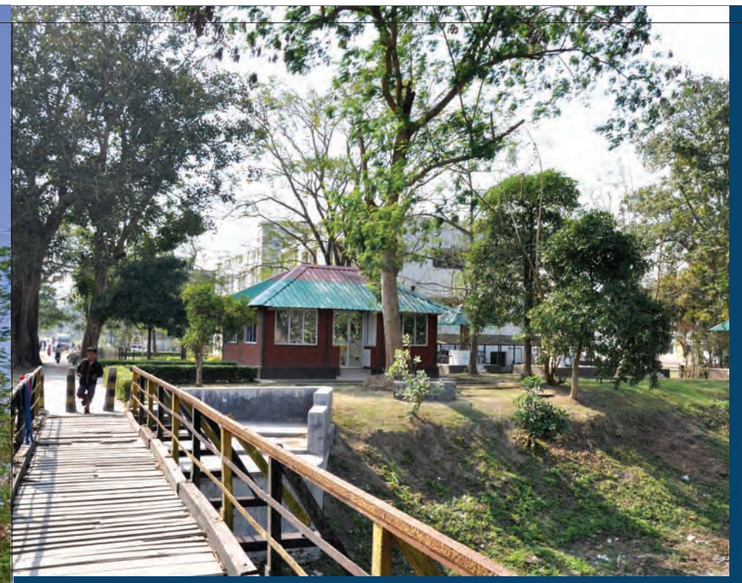
Proposed Course Structure for BS-MS/IPhD/RS programmes in Physics

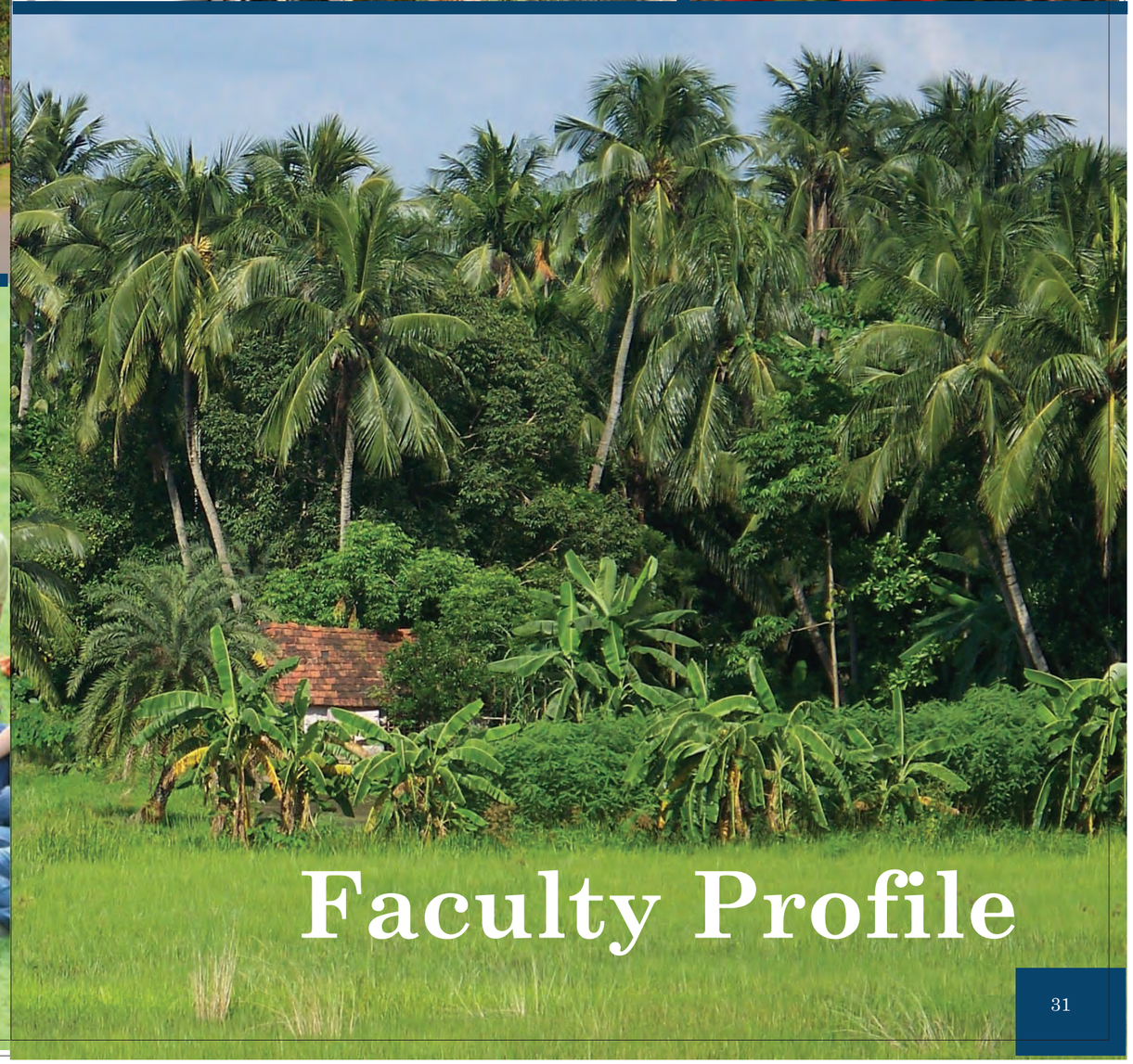
	Autumn Semester		Spring Semester	
Level 1	PH1101	Physics 1 [Mechanics, Optics, Quantum Mechanics] (3)	PH1201	Physics 2 [Thermal Physics, Electricity & Magnetism, STR] (3)
	PH1102	**Physics Lab 1 [Mechanics,Heat] (3)**	PH1202	**Physics Lab 2 [Electricity & Magnetism, Properties of Matter] (3)**
Level 2	PH2101	Physics 3 [Waves, Optics, Electricity & Magnetism] (3)	PH2201	Physics 4 [Mechanics, Quantum Mechanics, Particle Physics] (3)
	PH2102	Electricity and Electronics (2)	PH2202	Thermal Physics (2)
	PH2103	**Physics Lab 3 [Modern Physics, Electrical] (3)**	PH2203	**Physics Lab 4 [Electronics, Optics] (3)**
Level 3 (IPhD 1)	PH3101	Intermediate Classical Mechanics (3)	PH3201	Basic Statistical Mechanics (3)
	PH3102	Intermediate Quantum Mechanics (3)	PH3202	Intermediate Electricity and Magnetism (3)
	PH3103	Mathematical Methods of Physics (3)	PH3203	Advanced Quantum Mechanics (3)
	PH3104	**Electronics Lab (3)**	PH3204	**Advanced Optics Lab (3)**
	PH3105	**Computational physics (3)**	PH3205	**Basic Nuclear Physics - Theory & Lab (3)**
		Minor (BS-MS) / Minor or Elective from below or Levels 1,2 (IPhD) (3)		Minor (BS-MS) / Minor or Elective from below or Levels 1,2 (IPhD) (3)
		Minor (BS-MS) / Minor or Elective from below or Levels 1,2 (IPhD) (3)		Minor (BS-MS) / Minor or Elective from below or Levels 1,2 (IPhD) (3)
Level 4 (IPhD 2)	PH4101	Basic Condensed Matter Physics (3)	PH4201	**Introduction to Experimental Research (3)**
	PH4102	Basics of Field Theory and Relativistic QM (3)	PH4202	Seminar Course (3)
	PH4103	Introductory Astrophysics (3)	Elective1	Choose from below (both BS-MS and IPhD) (3)
	PH4104	**Condensed Matter Laboratory (3)**	Elective2	Only for BS-MS, choose from below (3)
	Elective1	Only for BS-MS, choose from below (3)	Elective3	Only for BS-MS, choose from below (3)
	Elective2	Only for BS-MS, choose from below (3)	Elective4	Only for BS-MS, choose from below (3)
			PH4203/ PH5203	Advanced Statistical Mechanics (IPhD Compulsory) (3)
		IP Project (9 credits)		IP Project (9 credits)
				Comprehensive Examination for IPhD
Level 5 (IPhD 3/ RS 1)	PH5101	BS-MS Project (9)	PH5201	BS-MS Project (12)
	Elective1	Choose from below (BS-MS/IPhD only)/Choose from below and Levels 3,4 (RS only) (3)	Elective 1	Choose from below (BS-MS/IPhD only)/Choose from below and Levels 3,4 (RS only) (3)
	Elective2	Choose from below (BS-MS only)/Choose from below and Levels 3,4 (RS only) (3)	Elective 2	Choose from below and Levels 3,4 (RS only) (3)
	PH5102	Faculty rotation (RS only - Autumn entry) (3)	PH5202	Faculty Rotation (RS only - Spring entry) (3)
		Comprehensive Examination for RS - Spring entry.		Comprehensive Examination for RS - Autumn entry
		Autumn (Aug-Nov) Electives		**Spring (Jan-Apr) Electives**
Electives	PH3106	Reading Project (3) (IPhD 1st year only)	PH3206	Reading Project (3) (IPhD 1st year only)
	ID4105/ ID5105	Evolutionary Dynamics (3)	PH4203/ PH5203	Advanced Statistical Mechanics (IPhD Compulsory/ BS-MS, RS elective) (3)
	PH4106/ PH5106	**Workshop and Vacuum Techniques (3)**	ID4204/ ID5204	Nonlinear Dynamics (3)
	PH4107/ PH5107	Non-equilibrium Statistical Mechanics & Diffusion (3) (Prereq: Basic Statistical Mechanics)	ID4205/ ID5205	Continuum Mechanics (3)
	PH4108/ PH5108	Advanced Condensed Matter Physics (3) (Prereq: Advanced Statistical Mechanics)	PH4206/ PH5206	General Theory of Relativity & Cosmology (3) (Prereq: Advisory committee guidance)
	PH4109/ PH5109	Quantum Field Theory (3) (Prereq: Basics of Field Theory and Relativistic Quantum Mechanics)	PH4207/ PH5207	High Energy Physics (3) (Prereq: Basics of Field Theory and Relativistic Quantum Mechanics)
	PH4110/ PH5110	**Advanced Physics Laboratory-I (3)**	ID4208/ ID5208	Biological Physics (3)
	PH4111/ PH5111	Advanced Mathematical Methods (3) (Prereq: Mathematical Methods of Physics)	PH4209/ PH5209	**Simulation Techniques and Data Analysis in Physics (3) (Prereq: Computational Physics)**
	PH4112/ PH5112	Quantum Optics & Computation (3) (Prereq: Advanced Quantum Mechanics)	PH4210/ PH5210	**Advanced Physics Laboratory-II (3)**
	PH4113/ PH5113	Quantum Magnetism (3) (Prereq: Advanced Quantum Mechanics)	PH4211/ PH5211	Nuclear Magnetic Resonance (3) (Prereq: Intermediate Quantum Mechanics and Basics of Condensed Matter Physics)
	PH4114/ PH5114	Advanced Electricity, Magnetism, and Optics (3) (Prereq: Intermediate Electricity & Magnetism)	PH4212/ PH5212	Advanced Soft Condensed Matter Physics (3) (Prereq: Advanced Statistical Mechanics)
	PH4115/ PH5115	Advanced Atomic & Molecular Physics (3) (Prereq: Advanced Quantum Mechanics)	PH4213/ PH5213	Advanced Astrophysics (3) (Prereq: Introductory Astrophysics)
	PH4116/ PH5116	Quantum Gravity and String Theory (3) (Prereq: General Theory of Relativity AND Basics of Field Theory and Relativistic Quantum Mechanics)	PH4214/ PH5214	Field Theories in Condensed Matter Physics (previously Many Body Theory) (3) (Prereq: Basic Condensed Matter Physics)
	PH4117/ PH5117	Quantum Transport (NKN course) (3)	PH4215/ PH5215	Fluid Dynamics (NKN course) (3)
	PH5120	Independent Study (3) (Every year) (RS/IPhD 3rd yr+ only)	PH5220	Independent Study (3) (Every year) (RS/BS-MS 10th sem/IPhD 3rd yr+ only)



Explanation of the course structure:

This is the proposed consolidated course structure for all three programs (BS-MS, IPhD, &PhD) in the Department of Physical Sciences, IISER Kolkata. The structure in this form is expected to be in effect from August, 2013. Levels 1 to 5 correspond to the years 1 to 5 for the BS-MS course work. BS-MS students study all 5 disciplines in level 1, and 3 pre-major disciplines in level 2 (of which only the physics courses are listed here) before continuing as physics majors in level 3 onwards. 1st year IPhD students start their course work concurrently with 3rd year physics major students (BS-MS) at level 3. However, for the optional 4 courses in level 3, the IPhD students may opt, in addition to minors, for physics courses at *any* level. For both BS-MS and IPhd projects, some credits can be commuted to take regular courses at the discretion of the department. The research scholars (RS) are regular PhD students who take courses with 3rd year IPhD or 5th year MS students. However, in consultation with the advisors, they are allowed to choose courses from level 3 as well. Most electives are suitable for both levels 4 & 5. Some of them, however, require prerequisites, and are offered at only level 5. Almost all courses are of three credits, requiring, for example, three lecture hours per week. The experimental courses are depicted in bold. All the elective courses are listed separately (in dark green). Only a few of them are offered on a regular basis, and we may switch allotted semesters for one to make it suitable for a certain batch of students. The BS-MS and IPhD students are admitted only in autumn, whereas the research scholars (RS) are admitted both in autumn and spring.





Faculty Profile

Ayan Banerjee
Assistant Professor
ayan@iiserkol.ac.in

Experimental studies of mesoscopic systems in optical tweezers and optical micromanipulation of matter

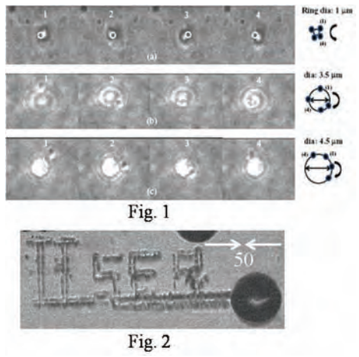


Fig. 1

Fig. 2

Fig. 1. Controlled transport of a soft oxo metalate (SOM) peapod due to enhanced SOI in optical tweezers.
Fig. 2. Pattern formation by controlled nucleation of a SOM in optical tweezers. Dimensions in μm.

Optical tweezers facilitate controlled experiments with mesoscopic matter ranging from nanoparticles to biological cells – the species being confined using light in a well-characterized fluid environment. Ayan's group has a working optical tweezers system in their lab to study diverse problems in a truly interdisciplinary mode of research. On the physics front, the group is probing the spin-orbit interaction (SOI) in tightly focused light that is used to trap particles in optical tweezers, and the manifestation of SOI in mesoscopic systems (Fig. 1). Other than this, studies are also underway on Brownian motion of trapped particles and interaction of different trapped soft matter species with light. The group has collaborations with Chemistry and Biology departments of IISER-K, and has interesting results in controlled photo-nucleation in optical tweezers using which they have written permanent patterns on glass substrates (Fig. 2). Studies are also underway on elasticity properties of biological cells in normal and stressed conditions so as to develop novel diagnostic techniques at the single cell level.

Selected Publications:

Self-assembly of microparticles in stable ring structures in an optical trap, Haldar, A., Pal, S. B., Roy, B., Dutta Gupta, S., and Banerjee, A., 2012, Physical Review A, 85, 033832

Measurement of probe displacement to the thermal resolution limit in photonic force microscopy using a miniature quadrant photodetector, Pal, S. B., Haldar, A., Roy, B., and Banerjee, A., 2012, Review of Scientific Instruments, 83, 023108

Probing the dynamics of an optically trapped particle by phase sensitive back focal plane interferometry, Roy, B., Pal, S. B., Haldar, A., Gupta, R. K., Ghosh, N., and Banerjee, A., 2012, Optics Express, 20, 8317

Saturated-absorption spectroscopy: eliminating crossover resonances by use of copropagating beams, Banerjee, A. and Natarajan, V., 2003, Optics Letters, 28, 1912

Precise frequency measurements of atomic transitions by use of a Rb-stabilized resonator, Banerjee, A., Das, D., and Natarajan, V., 2003, Optics Letters, 28, 1579

PhD Students:

Basudev Roy, Sudipta Bera

Ayan Banerjee obtained his PhD in Physics from the Indian Institute of Science in 2005. Subsequently he was a Research Scientist at General Electric Global Research, Bengaluru. He won the 'Innovation Award' in GE in the years 2007 and 2008. Ayan joined IISER-K in 2009 as Assistant Professor in Physics.

Narayan Banerjee
Professor
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General Relativity and Cosmology

Recent observations tell us that the Universe at present is undergoing an accelerated expansion. This is counterintuitive as the dynamics of the Universe is governed by gravity, which is always attractive. In general relativity the pressure of the matter distribution also plays a role in the gravitational interaction. There is therefore a search for some matter, dubbed as Dark Energy, which yields an effective negative pressure sufficient to give rise to a repulsive gravity. Narayan Banerjee at present is involved in this search for a suitable Dark Energy.

Narayan is also interested in gravitational collapse to check whether the end of a star is in a black hole or in a naked singularity. Recently he is also working on quantizing cosmological models.

Selected Publications:

Brans-Dicke scalar field as a chameleon, Das, S., Banerjee, N., 2008, Phys. Rev. D, 78, 043512

Generalized scalar tensor theory and the cosmic acceleration, Banerjee, N., Ganguly, K., 2009, Int. J. Mod. Phys. D, 18, 445

Collapse of non-spherically symmetric scalar field distribution, Ganguly, K., Banerjee, N., 2011, Gen. Relativ. Gravit., 43, 21

Perfect Fluid Quantum Anisotropic Universe: Merits and Challenges, Majumder, B., Banerjee, N., 2013, Gen. Relativ. Gravit., 45, 1

Modified Ricci flow and asymptotically non-flat spaces, Chatterjee, S., Banerjee, N., 2013, Canadian Journal of Physics (in press)

PhD Students:

Anjan Ananda Sen, Somasri Sen, Sudipta Das, Supratik Pal, Koyel Ganguly, Manjari Bagchi, Barun Majumder, Nandan Ray, Ankan Mukherjee, Soumya Chakraborty

Narayan Banerjee obtained his Ph.D. from Jadavpur University in 1986. Subsequently he taught at Sripat Singh College in Murshidabad. He Joined Jadavpur University in 1991 and moved to IISER Kolkata in 2008.

Soumitro Banerjee
Professor
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Bifurcation theory for non-smooth systems

In many dynamical systems it has been found that a small variation in a parameter may result in a *qualitative change* in the steady state behaviour. Such events are called bifurcations --- which have been the subject of investigation of Dr. Banerjee. He has mainly concentrated on "hybrid dynamical systems" like switching electronic circuits and mechanical systems with impacts or stick-slip motion, which involve continuous-time evolution as well as discrete switching action between two or more different types of dynamical behaviour. Dr. Banerjee's pioneering contribution has been in demonstrating that such systems undergo a special kind of qualitative change, known as "border collision bifurcation." He has been instrumental in developing the mathematical theory of border-collision bifurcations, which has been widely used in various application areas to understand why certain abrupt and drastic changes occur in the dynamical state of a system. He has also been in the forefront of the investigations on the nonlinear phenomena in power electronics.

Selected Publications:

Robust Chaos, Banerjee, S., Yorke, J. A., and Grebogi, C., 1998, Physical Review Letters, 80, 3049

Border Collision Bifurcations in Two-Dimensional Piecewise Smooth Maps, Banerjee, S., Grebogi, C., 1999, Physical Review E, 59, 4052

Invisible Grazings and Dangerous Bifurcations in Impacting Systems: the Problem of Narrow-band Chaos, Banerjee, S., Ing, J., Pavlovskaia, E., Wiercigroch, M., Reddy, R. K., 2009, Physical Review E, 79, 037201

Books: "Nonlinear Phenomena in Power Electronics" (Ed: Banerjee and Verghese, IEEE Press, 2001), "Dynamics for Engineers" (Wiley, London, 2005), and "Wind Electrical Systems" (Oxford University Press, New Delhi, 2005)

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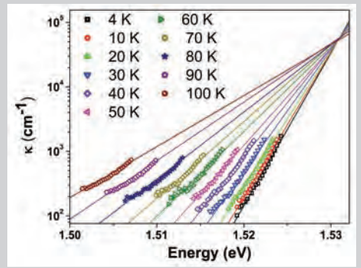
Physics of excitons: Understanding light emission from semiconductors

While semiconductor-based light emitting devices are already ubiquitous, many specific aspects of the physics of light-matter interaction are ill-understood. This is especially true in novel materials where disorder is significant, the role of the band structure in the optical properties is not well understood, or if one wants to understand the dynamics on the (sub-) picosecond time scales. A deeper understanding of these issues is important for gauging the viability of different ideas and materials for next generation optoelectronic devices, and fun because semiconductors often manifest as clean examples of text-book quantum mechanics at play.



Urbach tail in GaAs quantum well seen in their optical absorption spectrum. Understanding the origin of these, universally observed exponential slopes of the absorption edge below the fundamental gap which meet at a focus, is a 60-year old problem that the Semiconductor Spectroscopy group has tried to address.

Bhavtosh is an experimentalist interested in spectroscopic investigations of semiconductor nanostructures (quantum wells and quantum dots) and mismatched semiconductor alloys. The primary technique he uses is low-temperature photoluminescence, in steady state and in the form of picosecond excitation-correlation spectroscopy. The development of a pulsed magnet set up for studying optics of semiconductor nanostructures in high magnetic fields is another current activity of his group.

Selected Publications:

On Conversion of Luminescence into Absorption and the van Roosbroeck-Shockley Relation, Bhattacharya, R., Pal, B., Bansal, B., 2012, Applied Physics Letters, 100, 222103

High-field Magneto-photoluminescence of Semiconductor Nanostructures (Review), Hayne, M., Bansal, B., 2012, Luminescence, 27, 179

Charge Separation and Temperature-Induced Carrier Migration in $Ga_{1-x}In_xN_yAs_{1-y}$ Multiple Quantum Wells, Nuytten, T., Hayne, M., Bansal, B., Liu, H.Y., Hopkinson, M., Moshchalkov, V.V., 2011, Physical Review B, 84, 045302

Extended excitons and compact heliumlike biexcitons in type-II quantum dots, Bansal, B., Godefroo, S., Hayne, M., Medeiros-Ribeiro, G., Moshchalkov, V.V., 2009, Physical Review B, 80, 205317

Excitonic Mott transition in type-II quantum dots, Bansal, B., Hayne, M., Geller, M., Bimberg, D., Moshchalkov, V.V., 2008, Physical Review B, 77, 241304

PhD Students:

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