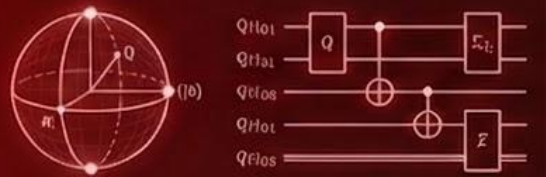
PhD Brochure

Department of Physics, IITH

Year 2026

- Introduction
- High Energy Physics (Theory & Experiment)
- Astronomy and Astrophysics
- Quantum Condensed Matter Physics and Statistical Mechanics (Theory)
- Experimental Condensed Matter Physics
- Optics, Lasers, Photonics, Metamaterials, Spectroscopy and Laser-Plasma Physics
- Quantum Information and Quantum Technologies: Theory *(No selection for this round)*
- Eligibility Criteria and Application Procedure



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Introduction

Thank you for your interest in the PhD program with the Department of Physics at IIT Hyderabad!

We hope that you will carefully review the information provided here to help you find out about the exciting opportunities we offer to pursue doctoral research in some of the most cutting edge & dynamic areas of physics and how you can apply.

The Department of Physics at IIT Hyderabad is a rapidly growing department. Presently we have 33 permanent faculty members, a number which we actively seek to increase, more than 100 PhD students and a large number of MSc, MTech and BTech (in Engineering Physics) students.

The department has several groups pursuing research in diverse areas of physics. Currently their efforts are concentrated mainly in the the following fields:

- High Energy Physics (Theory & Experiment)
- Astronomy & Astrophysics
- Computational Condensed Matter Physics (Quantum/Classical)
- Experimental Condensed Matter Physics
- Optics, Photonics, Spectroscopy and Laser-Plasma Physics
- Quantum Information and Quantum Technologies: Theory ***(No selection of PhD candidates for this round)***

There are usually several project-funded PhD openings in addition to the institute funded PhD seats, and the details of these can be shared during the interview.

PhD Curriculum: The IITH Physics Department is dedicated to providing the PhD students with both a broad background and in-depth training in their area of specialized research. Once admitted to the PhD program, the student has to earn 12 credits to complete his or her coursework requirements for a PhD. We offer intensive training in the fundamental topics of Physics through the core courses to prepare our PhD students for the challenges that lie ahead in their academic journey. In addition to the core courses, specialized elective courses are offered to the PhD students in their respective areas of research.
Following the coursework, the PhD program is focused on full-time research. Students will work closely with their supervisors and interact with other members of their group, and also other groups. Further information on the elective courses offered and research of the various groups are provided in the following pages of this brochure. PhD students come into contact with an array of faculty and other members of the Physics community through journal clubs, public lectures and seminar series (organized by research areas). Students will also have an opportunity to travel abroad for an international conference to present research papers.

PhD Eligibility Criteria & Application Process: Please refer to the page detailing the eligibility criteria and application procedure if you are interested in pursuing a PhD with the Department of Physics, IITH.

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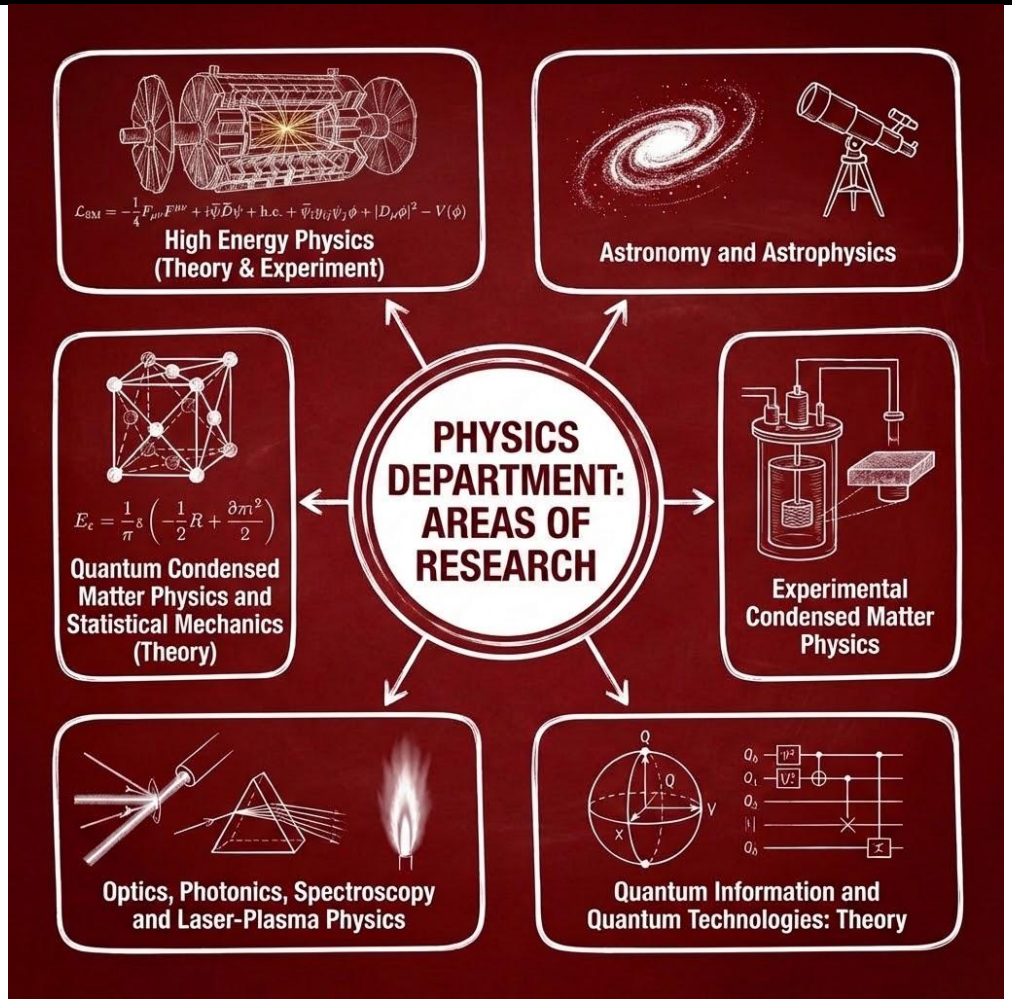


High Energy Physics (Theory & Experiment)

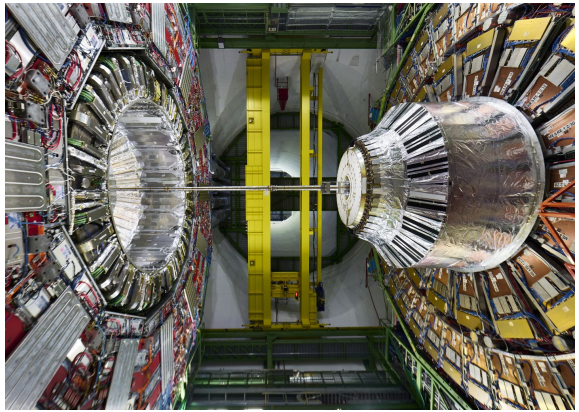
The High Energy Physics (HEP) group at IITH is looking for motivated PhD students to join us on a range of exciting projects.

Experimental High-Energy Physics is currently at the verge of groundbreaking discoveries and technological advancements. Advances in quantum computing and machine learning are also revolutionizing data analysis and simulation techniques. On the theoretical side, research is being pursued in several cutting edge areas to further our understanding of the fundamental nature of the universe.

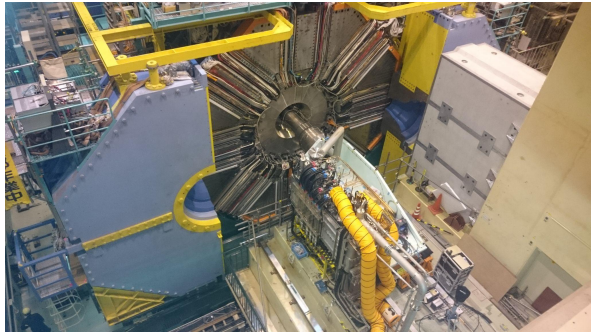
The activities of the group can be divided into two broad areas with different faculty members specialising in each of these: HEP Theory and HEP Experiment.

High Energy Physics Theory:
At our group, there is scope to do research in the formal aspects of theory (Quantum Chromodynamics, Nonperturbative aspects of field & string theory, Classical and Quantum Gravity), phenomenology targeting the latest collider searches (beyond the standard model, neutrinos, dark matter, Higgs).

High Energy Physics Experiment:
The Large Hadron Collider (LHC) at CERN continues to probe the frontiers of particle physics. The Experimental HEP group offers opportunities to perform experimental research based on the the Compact Muon Solenoid (CMS) experiment at the CERN Large Hadron Collider.
The Belle II experiment, located at the SuperKEKB accelerator in Japan, has been designed to make precise measurements of weak interaction parameters, study exotic hadrons, and search for new phenomena beyond the Standard Model of particle physics.



The CMS detector at the LHC



Belle II Detector at the SuperKEKB accelerator

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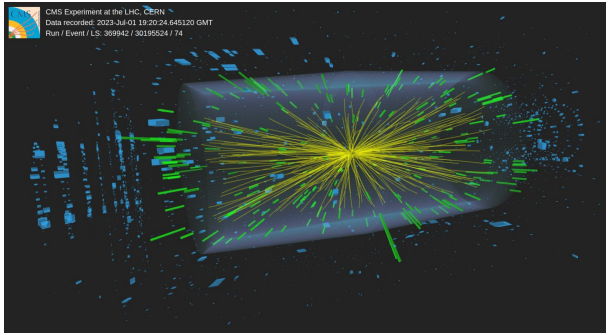
High Energy Physics (Theory & Experiment)

Group members are also working for the NOvA Neutrino collaboration at Fermilab, USA and the upcoming Muon g-2 experiment at JPARC, Japan.
A particle detector laboratory is under development and there will be opportunity to work on particle physics detectors and particle reconstruction.

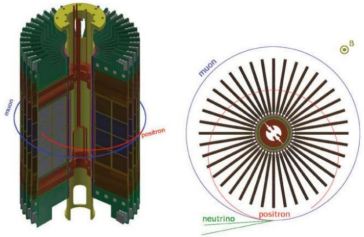
The HEP group members offer specialized elective courses to prepare students for research in these fields. Such electives include Quantum Field Theory, General Relativity, Advanced Particle Physics, Cosmology, Group Theory, Computational Particle Physics.
Following the course work, the Ph.D program is focused on full-time research. Students will work closely with their supervisors, and also interact with other members of the HEP group, participating fully in the life of the group including HEP Journal Clubs, Remote Seminar Series, HEP gym, GIAN courses, Workshops and Conferences (e.g. FFCP 2018, Phoenix 2023 & PPC 2024).

For further details, please visit the IITH HEP group webpage:
https://physics.iith.ac.in/research.html?tab=Research__areas
The webpage also contains the research profiles of individual faculty members.



Particles collisions at the CMS experiment at the LHC

NOvA Experiment



The upcoming muon g-2 experiment at JPARC, Japan

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Astronomy & Astrophysics

Observational Astronomy & Astrophysics:
The group offers research in astrophysical cosmology, astrostatistics, observational astronomy, pulsar timing studies, plasma astrophysics, etc.

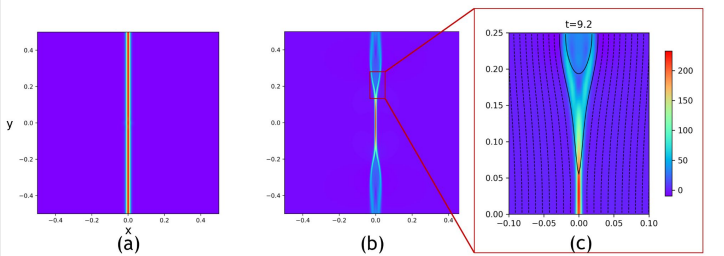
The institute also hosts an Advanced Dark Sky Observatory (ADO) with a 0.5-meter Robotic optical telescope. Certain members of the group are also part of experimental collaborations such as the Indian Pulsar Timing Array.

The Astrophysics group members offer specialized elective courses to prepare students for research in these fields. Following the course work, the Ph.D program is focused on full-time research. Students will work closely with their supervisors, and also interact with other members of the department to perform their research activities.

For further details, please visit the webpage of the Astrophysics group: https://physics.iith.ac.in/research.html?tab=Research__areas. The webpage also contains the research profiles of individual faculty members.

Collapse of Black Hole Binary

Advanced Dark Sky Observatory at IITH



Simulation of relativistic magnetic reconnection

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Quantum Condensed Matter Physics and Statistical Mechanics (Theory)

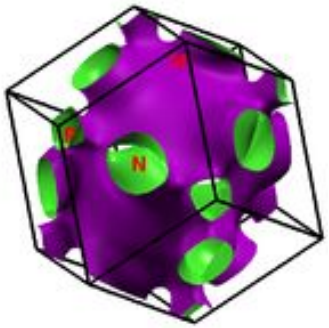
Research in the Theoretical Quantum Condensed Matter Physics and Statistical Mechanics group can be divided into three subgroups.

The first subgroup focuses on materials, which includes a diverse variety of topics such as basic electronic structure, phase transitions, magnetism, super-conductivity, optical properties, transport properties.

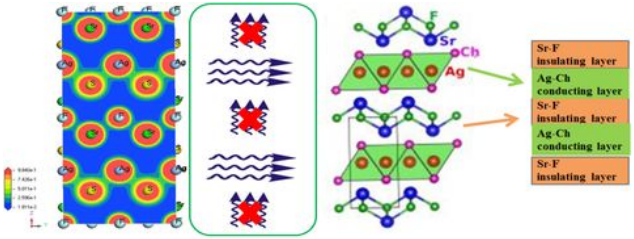
The second subgroup focuses on the study of complex systems like disordered systems, soft-matter, non-equilibrium statistical mechanics, bio-physics, and many more.

The third subgroup focuses broadly on quantum dynamics that includes non-equilibrium behavior, quantum chaos, quantum phase transitions, topological phases, Floquet phases, non-Hermitian systems, localization-delocalization transition in disordered systems, josephson junctions, quantum annealing etc.

This field of research has strong connections to cutting-edge applications, like graphene-like materials, biomimetic materials, cancer metastasis, which are high in demand now. In addition, one can find a huge range of applications such as topological qubits, detector systems, energy storage, superconducting materials,next-generation sensors etc.



Fermi Surface of $LaRu_4P_{12}$



Charge flow in a layered structure of *SrAgChF*

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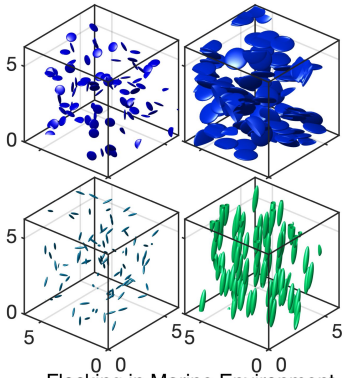
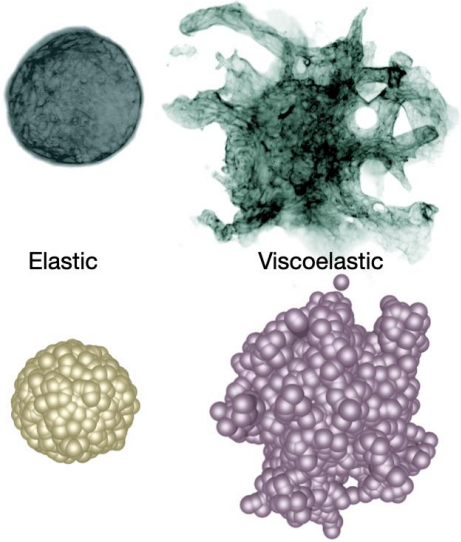
Quantum Condensed Matter Physics and Statistical Mechanics (Theory)



Flocking in Marine Environment



Tissue growth in viscoelastic matrix

Our group at IITH is actively involved in exploring various material properties using first-principle calculations to design high potential materials for different applications and develop models to understand complex systems such as viscoelastic flows, and biophysical systems.

For more details visit http://physics.iith.ac.in/index.html. We welcome applications from students who are strongly motivated to work with us on innovative problems in Condensed Matter Physics.

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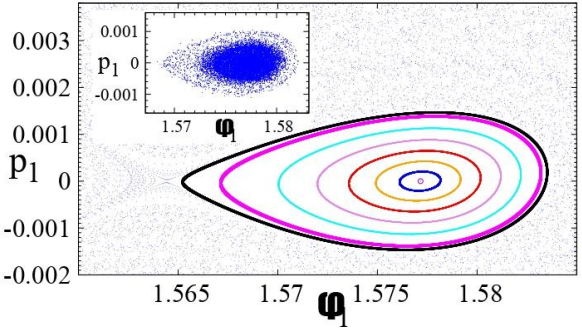
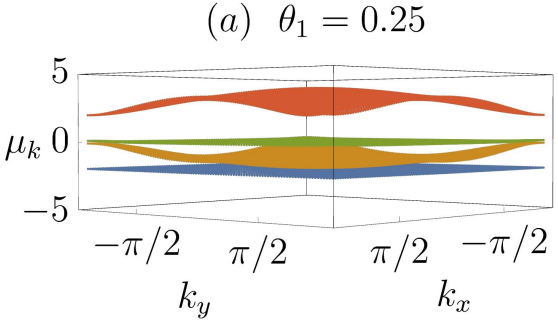


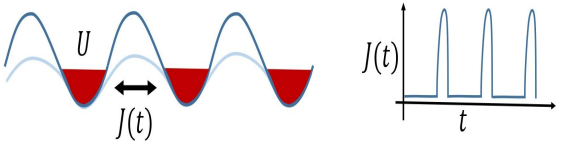
Many-body chaos

In the third subgroup, we focus on the interdisciplinary topics of condensed matter and statistical physics that include non-equilibrium dynamics, quantum chaos, quantum phase transitions, topological systems, Josephson junctions, Floquet phases, localization-delocalization transition in disordered systems, quantum annealing etc. We are also interested in working in quantum simulations for spin systems in both equilibrium and non-equilibrium scenarios.
The mentioned research direction is an active area of research worldwide, not only for their interesting fundamental physics, but also their applicability in building quantum computers and quantum simulators. The students will have scope here to learn both analytical and numerical techniques, and to apply those for realistic systems.

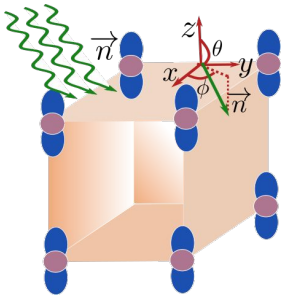
We welcome interested and motivated students in our group. To learn more, please visit the webpage of Department of Physics, IIT Hyderabad.



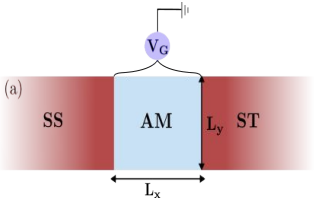
Floquet flat band



Bosonic josephson junctions



Floquet exceptional topological insulator generated via light irradiation



Diode effect in spin singlet superconductor- Altermaget-spin triplet superconductor Josephson junction

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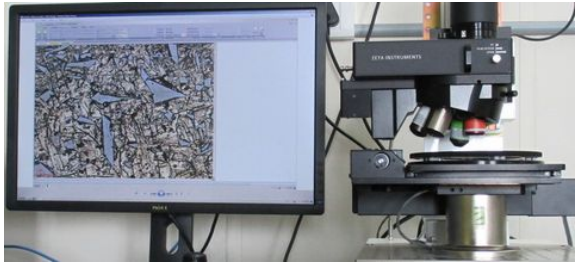
Experimental Condensed Matter Physics

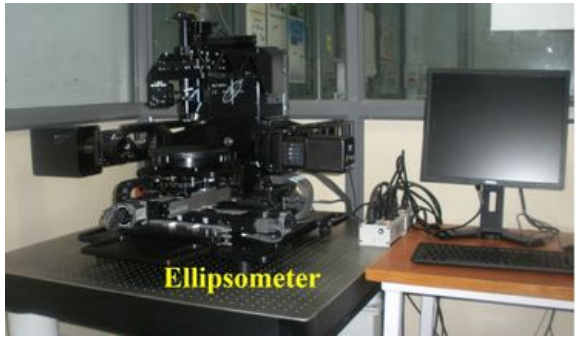
Understanding the fundamental physical concepts behind various materials, in particular, technological devices such as spin-electronics, semiconductor devices and nanoelectronics have been of great interest in recent past due to their strong potential for practical applications. On top of that today's technology demands smaller, faster and reliable devices. It is a challenge to understand the ultrafast time scale (10^{-9}s to 10^{-18}s) prevalent in these nanoscale systems brought about by processes involving fundamental interactions between electron, spin, phonon and their corresponding correlation length and time scales.

The experimental condensed matter physics group at IITH conducts vibrant research in frontier areas of physics such as spintronics, magnonics, magnetic materials, advanced functional materials, glass and silicon micromachining and microelectromechanical systems (MEMS).
We thus offer a diverse range of cutting-edge topics for students to work on. Research laboratories are equipped with state of the art experimental facilities, thereby providing direct hands-on experience. Faculty members in this group have strong national and international collaborations, which provide many opportunities for students to visit and interact during the course of their research.

Students can select a research field based on their interests and subject to the availability of vacancies with respective faculty members.

Courses for PhD scholars are designed in such a way that the students can attain very good understanding about their research field. The Physics department aims at





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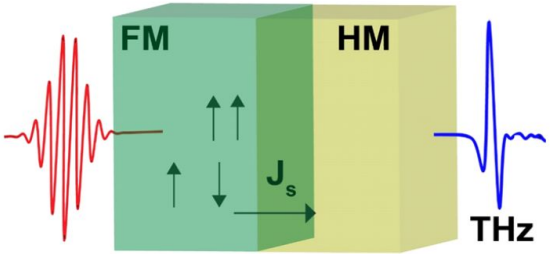
Experimental Condensed Matter Physics

strengthening the core physics course along with specialized elective courses. Some of the elective courses aimed at Ph.D students interested in working in our group, include experimental techniques, advanced functional materials, application of magnetic materials, microfabrication techniques, semiconductor device physics, spintronics and many more.

Alongside these areas, several multidisciplinary research directions employ the principles of condensed matter physics in optics, photonics, and spintronics. Ultrafast spintronics, in particular, has emerged as a rapidly developing area of research. It employs thin spintronic films for the generation of terahertz (THz) radiation and utilizes these ultrafast THz pulses to probe fundamental physical processes occurring on picosecond and even sub-picosecond timescales. This emerging field has become an important research frontier, and several of our Ph.D. students at IIT Hyderabad are pursuing cutting-edge research in this area. We are actively looking for students to work in this area.



Ultrafast Spintronics

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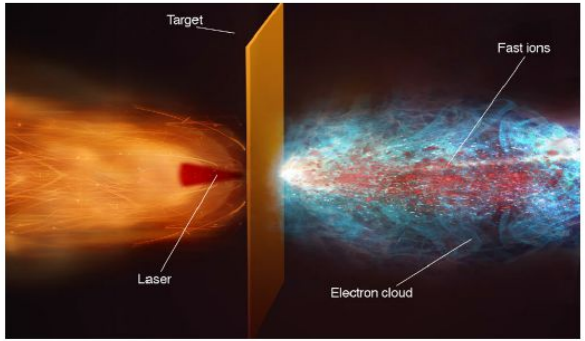
Optics, Lasers, Photonics, Spectroscopy and Laser-Plasma Physics

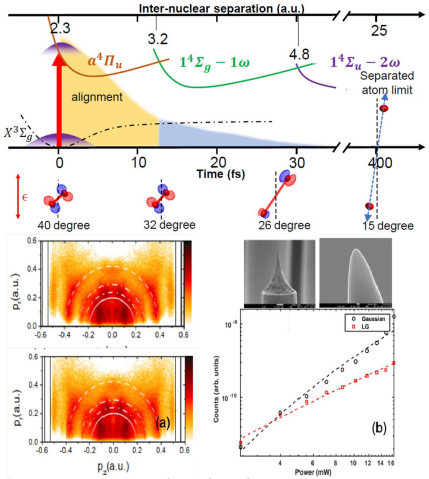
We are looking for highly motivated students with a strong interest in developing innovative experiments and theoretical understanding. Our group is committed to excellence in research and innovation, advancing scientific areas that have a meaningful impact on society. The interaction of laser pulses with matter is opening new frontiers in physics, driven by advances in ultrashort pulse laser technology. These advances enable probing the electronic structure of atoms and molecules, ultrafast control of quantum materials, and transient spectroscopy, while also supporting the development of tabletop accelerators, astrophysical plasma modelling and fusion energy, and novel devices for communication, photonics, and emerging quantum technologies.

Our group has opportunities in aspects of experimental and theoretical investigation such as:

- ultrafast dynamics of atoms and molecules,
- ultrafast nonlinear optics and time-resolved/optical pump-terahertz probe spectroscopy,
- table top X-ray source,
- ultrashort electron source,
- exciton dissociation dynamics at a donor/acceptor interface in an organic photovoltaic system,
- astrophysical, fusion, & intense laser plasmas,
- table top ion accelerators - Medical applications (ion cancer therapy).
- Photonics, superconductor photonics, nonlinear optics, Fiber optics, lasers and sensors,
- Plasmonics, Nanophotonics, Infrared imaging, Terahertz devices, Metamaterials, Spintronics



Plasma and Laser interaction



Atomic and Molecular Dynamics

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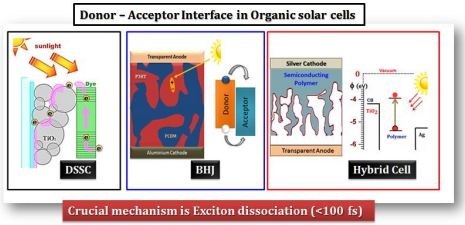
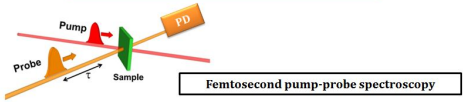
Optics, Lasers, Photonics, Spectroscopy and Laser-Plasma Physics

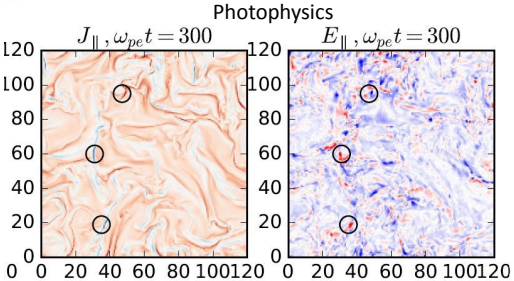
The group has active collaborations in various central laser, FEL and synchrotron facilities in the UK, US and Europe; NIMS Tsukuba, Tohoku and Osaka University in Japan.

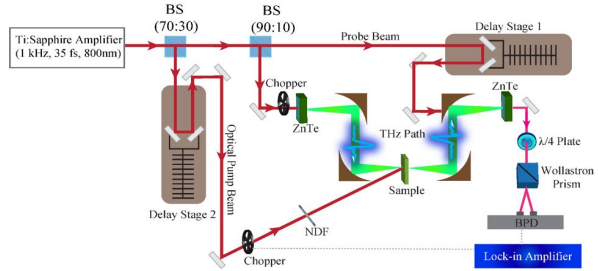
To find out more details please visit the group webpage listed on https://physics.iith.ac.in/research.html?tab=Research__areas,

which also provides links to profiles of individual faculty members.Specialized elective courses are offered to prepare students for research in Atomic, Molecular and Plasma Physics. Such electives include Lasers and Photonics, Plasma Physics, advanced courses in Atomic and Molecular Physics, Optical Engineering. Following the course work, the PhD program is focused on full time research. Students will work closely with their supervisors for designing experiments, and also interact with other members of the group. They can also pursue theoretical/numerical research. Students will have the opportunity to travel abroad for international conferences to present research papers and also to perform experiments at international facilities.

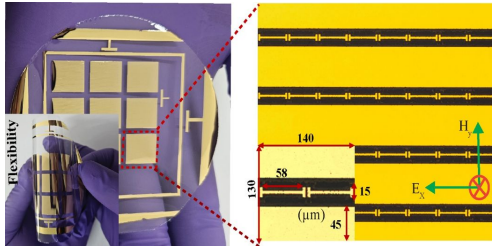








Optical pump terahertz probe spectroscopy setup at IIT Hyderabad



Flexible Ultrahigh Sensitivity Sensor

भारतीय सांकेतिक विज्ञान संस्थ हैदराबाद
भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

Department of Physics, IIT Hyderabad

Quantum Information Theory and Quantum Technologies

(NOTE: There will be no selection for this area in this round of PhD admissions)

భారతీయ సాంకేతిక విజ్ఞాన సంస్థ హైదరాబాద్

भारतीय प्रौद्योगिकी संस्थान हैदराबाद

Indian Institute of Technology Hyderabad

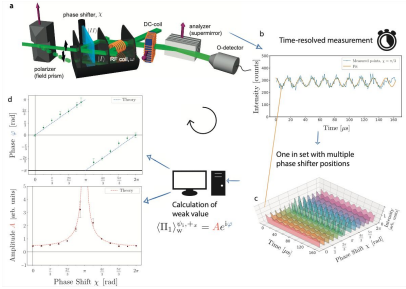
Department of Physics, IIT Hyderabad

We are looking for highly motivated students to pursue their research on various aspects of quantum information theory and quantum technologies. Research in this direction is carried out in two subgroups.

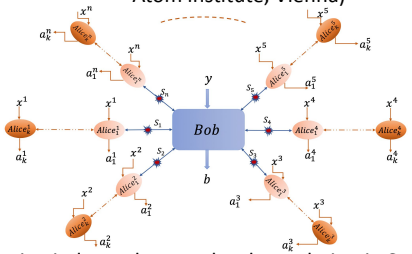
A) **Quantum Foundations to Quantum Technologies:** Quantum theory is astonishing. Despite its enormous success as a physical theory, there is still no consensus among physicists about what this theory is saying about the nature of reality. This is one of the many motivations for pursuing research on quantum foundations. Another is the development of quantum technologies, such as quantum computation, quantum cryptography, quantum metrology by exploiting its peculiar features. A better understanding of the theory facilitates the identification and development of these new technologies and also further the harnessing of the power of non-classicality. There may also be some special non-classical features that exist in nature providing advantage in some information processing task even if quantum theory is replaced by another physical theory in future.

In this subgroup, the students will have the scope and freedom of working in various interrelated research topics. The broad areas (not limited to) are the following; i) Quantum Foundations (nonlocality, contextuality, macrorealism, ψ-ontic and ψ-epistemic interpretation of quantum states) ii) Device-independent certification protocols (Random number generation, self-testing state, measurement and instruments based on prepare measure or entanglement based scenario) iii) Quantum information processing (Communication Complexity, Quantum channels, Quantum Thermodynamics) iv) device independent quantum cryptography (Theoretical analysis of the security of the key distribution, Error correction) iv) Quantum Network (Nonlocality in open and closed networks and applications in certification protocols) v) Quantum metrology and sensing (Standard parameter estimation technique, Quantum clock).

To find out more details please visit the IITH Quantum Information Theory group webpage: https://physics.iith.ac.in/research.html?tab=Research__areas Students may also propose their topics of interest under the above mentioned theme. We remain open for new ideas and opinions.



Testing commutation relation (Performed in Atom institute, Vienna)



Device-independent nonlocal correlation in Star-network

Quantum Information Theory and Quantum Technologies

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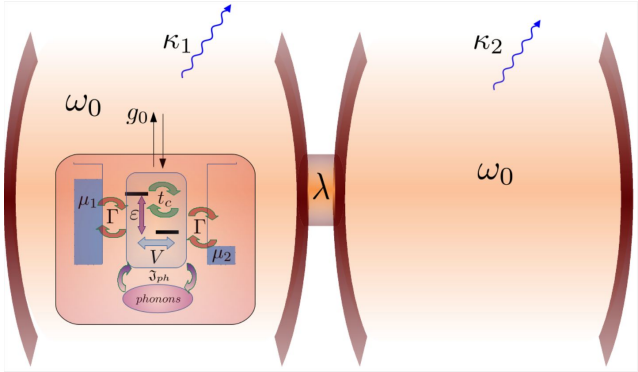
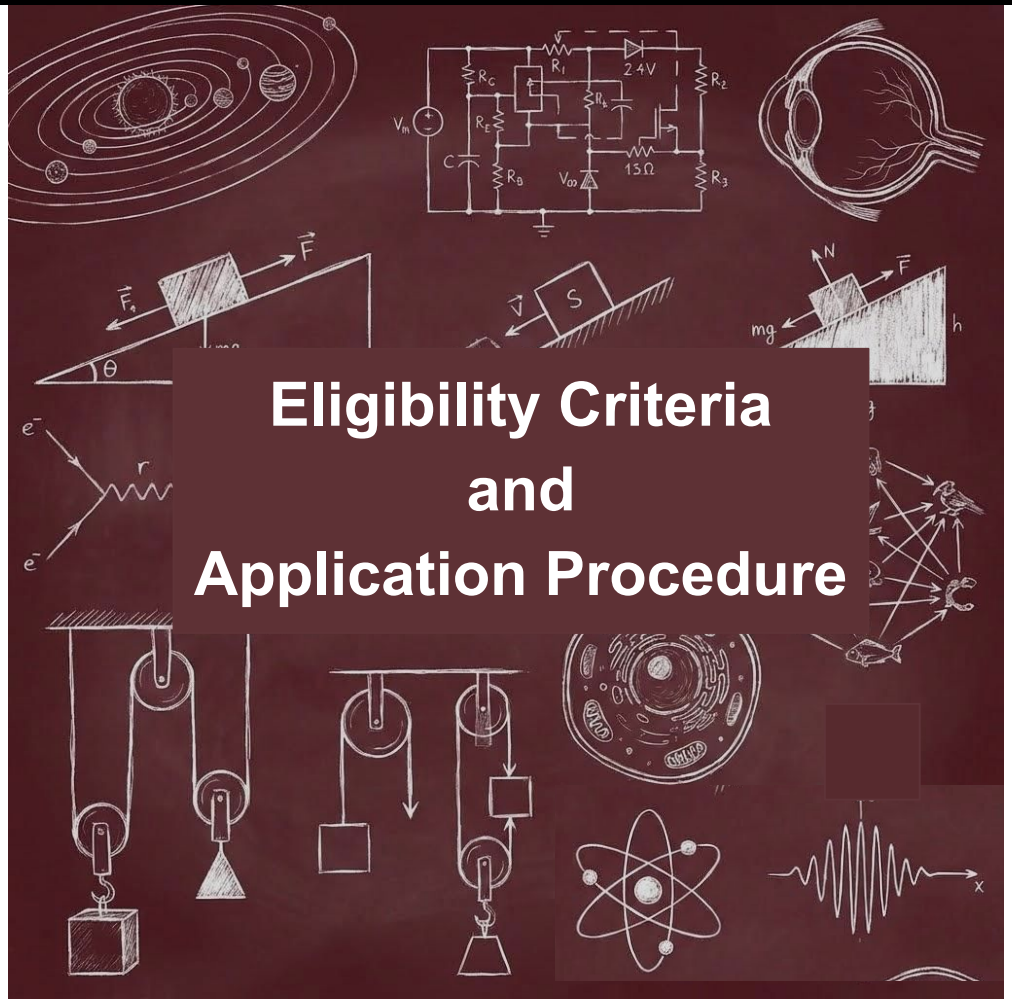
B) Physics of platforms for quantum technology: Advent of quantum technology requires scalable and tunable platforms where quantum effects can be controllably studied and utilized. At present some of the leading platforms in this regard are superconducting circuits, quantum dots, atoms and ions in optical traps, color centers in diamond. These platforms have shown promise for various applications like quantum sensing, quantum information processing, digital and analog quantum simulation. They are inherently noisy and dissipative because complete isolation from surrounding environments is not possible and often not even desired. Further, the applications require that these systems are driven out of equilibrium, for example via a time-dependent pulse or a voltage bias. Accurate theoretical modelling of the system under such conditions is crucial for many applications, like quantum sensing and quantum simulation. However, describing such driven dissipative quantum many-body systems is a major challenge. Most state-of-the-art theoretical formalisms for describing these systems are tractable and applicable only in a very restricted regime. This limits both our fundamental understanding and exploration of potential applications to a narrow regime of experimentally achievable parameters.

In this subgroup, we aim to go beyond these limitations. The broad goals of this subgroup are:
(i) develop analytical and numerical techniques to describe various platforms for quantum technology beyond present limitations, (ii) explore their exotic physics, both for fundamental understanding and potential applications, (iii) propose new platforms, novel working regimes and applications.

This research is at the interface of condensed matter physics, statistical physics, quantum information and quantum optics. The student has the freedom to explore one or more of the above directions more deeply, while having an overall understanding of the rest. There is scope for both analytical, mathematical research (linear algebra, diagrammatic techniques) as well as research based on development and application of sophisticated numerical approaches (tensor network and sparse matrix techniques). There is also ample scope for national and international collaborations.



Coupled cavities with a voltage biased double-quantum-dot in one of them.



Eligibility Criteria and Application Procedure

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Indian Institute of Technology Hyderabad

Eligibility and Application Procedure

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Indian Institute of Technology Hyderabad

Department of Physics, IIT Hyderabad

Eligibility Criteria

The PhD program at the Department of Physics, IITH takes in students either through the regular route or a special route for sponsored (external) candidates. The eligibility criteria for the applicants are laid out below:

For all Candidates:

- Candidates are required to have obtained at least 60% (for regular route only, relaxed to 54% for OBC-NCL, 51% for SC/ST/PWD) marks or equivalent CGPA in the preceding degree.
- Candidates through regular & sponsored routes must satisfy the eligibility criteria for the department mentioned below as well as those for the institute as mentioned on the application portal - the stricter eligibility criteria shall apply in case of any difference.

For Regular Ph.D. Candidates:

- MSc (Physics / Applied Physics / Electronics) or an equivalent degree in engineering (ME / MTech or MSc(Engg) etc.) with a valid Physics GATE score or UGC-JRF / CSIR-JRF / DST-INSPIRE Fellowship.

OR

- BTech/BE/BS(4 years) in Physics / aligned areas or equivalent engineering degree with a valid Physics GATE score.

Note: In certain admission rounds, a limited number of seats may be open for meritorious students from certain CFTI institutes via **Special Direct (High CGPA)** route without GATE requirement, with increased stipend. Please refer to the institute website for details.

For Sponsored (External) Candidates:

- Candidates working in reputed research or industrial organizations may apply for the sponsored PhD program with proof of sponsorship and NOC from parent organization. **Note:** Sponsored candidates are not eligible for stipend.
- MSc (Physics) or equivalent Masters degree in related areas.

OR

BTech/BE/BS(4 years) in Physics / aligned areas with at least 2 years of relevant work/research experience.

- Please contact the department for further eligibility criteria.

Application Procedure

- Applications for the Ph.D program are received twice (normally in March/April and October/November each year).
- Please look for PhD advertisement on the institute website for exact dates.
- Eligible candidates will be further shortlisted based on their performance in the qualification examination & degree required for eligibility and then invited for further interviews (or examination) that will be conducted for final selection.

Note: Rolling admissions are applicable for applicants with UGC-JRF/CSIR-JRF/DST-INSPIRE Fellowship at any time.

Further Information

If you are interested in the activities of a particular research group or a particular faculty member at IITH Physics and are exploring the possibility of pursuing a PhD, **please send an email to the particular faculty.** Please check the departmental website for potential research areas. One can also contact the Head of Department of Physics for further information.

Prof. Manish K. Niranjan,
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Indian Institute of Technology Hyderabad
Kandi 502285, Telangana, India

Contact: phd.admissions@phy.iith.ac.in