भारतीय प्रौद्योगिकी संस्थान कानपुर
Indian Institute of Technology Kanpur

PHYSICS

POST GRADUATE PROGRAM

PHYSICS

The Department of Physics at IIT Kanpur is reputed for its high quality academic programme and research in front-line areas of both fundamental and applied importance. The Department has at present 53 members in the Faculty assisted by a team of DST-Inspire Faculty Fellows and Postdoctoral Fellows as part of the academic staff. There are over 200 research scholars engaged in doctoral research at present.

The Department participates in the undergraduate Core Courses in the B.Tech. Programme, and BS (4 yr) + MS (1 yr) Programme in Physics (making effective use of the flexibility in the new credit-based undergraduate Programme, with options for minor and double major in different disciplines) which includes basic and engineering sciences, workshop practices, courses on computation as well as courses on humanities and social sciences. The Department has a M.Sc. (2 yr) Programme as well as a Ph.D. Programme with specialization in many major areas of Physics. The Physics Department also offers a unique time-saving M.Sc. - Ph.D. (Dual Degree) Programme for those seeking to take advantage of our M.Sc. training to accelerate their progress in doctoral work. Further, there is a large variety of courses offered by the Physics Faculty that are of interest to a number of Inter-Disciplinary Programmes of the Institute. The Physics Department also participates in the Laser Technology and the Materials Science Programmes of the Institute.

The Department actively participates in frontline research in several major areas of Physics. The five main broad classes in which these research areas may be classified are:

(i) Complex Systems
(ii) Condensed Matter Experiments (including ion beam, plasma and nuclear solid state)
(iii) Condensed Matter Theory
(iv) High Energy Physics
(v) Photonics and Quantum Technologies.

POST-GRADUATE PROGRAMMES OFFERED

PH.D. PROGRAMME

The Department of Physics offers many subdisciplines in the Ph.D. programme. The requirements in the various programmes are prescribed to ensure that the scholars acquire enough professional maturity to enable them to deal with a wide range of research problems in their respective fields of specialization.

The research interests of the department include topics in Atomic and Molecular Physics, Plasma Physics, Biological and Statistical Physics, Computational Physics, Dynamical Systems, Turbulence and Non-linear Physics, Fluid Dynamics, Evolutionary Games, , Soft Matter, Active Matter, Particle Physics, Beyond Standard Model phenomenology, QCD, Lattice Gauge Theories, Quantum Field Theory, Astrophysics, Cosmology, String Theory and Quantum Gravity - AdS/CFT - Hydrodynamics, Biophotonics, Light-Matter Interaction, Photonics of Micro and Nano Structured Materials, Non-linear Optics, Fiber Optics, Quantum Optics, Laser Cooling and Trapping, Experimental and Theoretical Condensed Matter Physics of strongly correlated electron systems, topological and nanomaterials; magnetism and superconductivity, semiconductor and magnetoelectronic devices, etc; Ion Beams and Nuclear Physics Techniques, with a substantial degree of Inter-Disciplinary activity.

Students with good academic record and strong motivation for a career in Physics can apply for admission to the Ph.D. Programme after earning Master's degree (or the new BS 4-yr degree). The programme combines course work, guided research, independent study and teaching assignments, all designed with a view to making the scholar a professional physicist. The Ph.D course work consists of many pertinent and exciting elective courses that cover the ongoing research areas in the department.

ELECTIVE COURSES

- Advanced general relativity and black holes
- Advanced quantum and statistical mechanics
- Advanced quantum mechanics
- Advanced statistical mechanics
- Astrophysics
- Coherence & quantum entanglement
- Coherent optics
- Computational simulation methods in physics
- Concepts of plasma physics
- Condensed matter II
- Condensed matter phenomena in low dimensional materials
- Cooperative phenomena in classical & quantum systems
- Correlated electrons and quantum magnetism
- Cosmology
- Density functional theory
- Electronic structure of materials
- Techniques in Experimental High Energy Physics

- Gauge theory and renormalization
- General relativity & cosmology
- Green nanotechnologies
- Group theory and its applications to particle physics
- High Energy Physics II
- Introduction group theory & its application to quantum mech.
- Introduction to astrophysical fluid
- Introduction to biophotonics
- Introduction to conformal field theory
- Introduction to high performance computing and machine learning
- Introduction to high performance computing for scientists and engineers
- Introduction to spintronics
- Introduction to x-ray neutron scattering
- Low temperature physics
- Magnetism in materials
- Mathematical methods II
- Measurement techniques
- Metamaterials & plasmonics
- Machine Learning in Particle Physics
- Non-equlibrium statistical mechanics
- Nonlinear system & dynamics
- Nuclear techniques in solid state studies
- Particle physics
- Photonic devices
- Physics and technology of thin films
- Physics of life
- Physics of natural nano-machines
- Physics of semiconductor nanostructures
- Physics of turbulence
- Principles of lasers and detectors
- Quantum electronics
- Quantum dynamics, information and computation
- Quantum dynamics: computation & information
- Quantum field theory
- Quantum many body physics
- Quantum optics
- Quantum phases in nano-scale system
- Quantum Technology
- Review of classical electrodynamics
- Review of classical machanics
- Review of mathematical methods in physics
- Review of quantum mechanics
- Review of statistical mechanics
- Soft matter physics
- Soft matter: concepts and methods
- Special & general relativity
- Special topics in quantum mechanics

- Stochastic dynamics of cognition
- Superconductivity and applications
- The standard model of fundamental physics
- Theory of random processes and applications
- Thermal physics at nano-scale
- Topics in semiconductor
- Transport in mesoscopic systems
- Turbulence in space plasmas
- Type II superconductors vortices & applications
- High Performance Computing with Applications

MAJOR RESEACH FACILITIES

Condensed Matter Physics:

Nitrogen and Helium Liquefiers, Superconducting magnets (up to 14 Tesla), Closed cycle Helium Refrigerators (down to 1.3 K), Experimental Setup for Resistivity, Hall Effect and Magnetic Susceptibility, Magnetoresistance, Specific Heat, Thermoelectric Power, Tunneling Conductance, Magnetostriction, Ultra high vacuum scanning probe microscope, superconducting quantum interference device (SQUID) based Magnetic Properties Measurement System (MPMS) with 10-6 emu resolution and 1.7K - 350K temperature range and magnetic field up to 5 Tesla. We also have a Physical Properties Measurements System (PPMS) with a 14 tesla superconducting magnet and helium–3 fridge with 300 mK base temperature. Scanning electron microscope (SEM) with electron beam lithography facilities for nano-scale patterning have been installed recently.

Some homemade facilities like variable temperature (8K - 300K) scanning tunneling microscope (STM) with atomic resolution and conductance imaging, magneto-optic Kerr effect (MOKE) imaging of magnetic surfaces, Pulsed Excimer Laser ablation facility for synthesis of magnetic, superconducting and dielectric superlattices, high frequency measurements of vortex dynamics in superconductors, Raman and micro-Raman Spectroscopy set-up for correlated systems. There are also experimental set ups for Dielectric measurement including Ferroelectric hysteresis of bulk and thin film materials, Thermal expansion measurement, Broadband FMR spectroscopy of ultra-thin films, and Inverse Spin Hall Effect measurement.

Well-equipped facilities have been setup for opto-electronic characterization of semiconductor materials and devices. State of the art research facilities for organic semiconductors are available. The Department participates in major projects on Organic Electronics through Samtel Centre for display Technologies. For micro-fluidics, we have contact angle Goniometer, fluorescent microscope and high speed (10,000 fps) camera.

Optics Laboratories:

ND:YAG lasers, Excimer Laser, Double Monochromators, Photon Counters, Spectrofluorimeter, Box Car Averagers, Vibration free tables. Facilities exist for High Resolution Spectroscopy, Micro-Raman Spectroscopy, Laser based pump-probe measurements, Laser-Plasma Studies and Nonlinear Optics, Diode Lasers, spectrograph-CCD system, Optical Spectrum Analyzers and Fibre Optics System, Optical Lithography Set-up, Atomic Force Microscopy Facility (Park XE 70 machine with a 100micron X 100 micron scanner head and a liquid cell). Two new Labs - Quantum and Nano-Optics, Quantum Optics and Entanglement Lab. are being set up.

Ion Beam and Nuclear Techniques Laboratory:

Mossbauer Spectrometer, Tandem particle accelerator, focused ion beam (FIB) with SEM column (Nova Lab 600) for Nano Microfabrication down to nm scales, modern 1.7 MeV Tandetron accelerator with capabilities of producing ion beams of almost all elemental species. The facility is equipped with a nuclear microprobe station for science

MAJOR RESEACH FACILITIES

and engineering applications such as proton and heavy ion beam writing, RBS, PIXE and ion Channeling E-beam deposition, Positron Annihilation, Mossbauer Studies at Low Temperatures.

Computational Facilities:

Physics cluster (Newton): 396 cores, 1.5 TB memory, Infiband switch. Chaos I: 256 cores, ½ TB RAM, Gigabit switch. Chaos II: 128 cores, ½ TB RAM, Two K10 GPU cards, Infiband switch. Many workstations including 3D capable visualisation stations. Dirac cluster for electronic structure calculations, 96 cores, 768 GB RAM. In addition, there are the following Institute facilities :hpc Cluster 1: 2994 cores, 100 TB storage, Peak rating 34.5 Tflops (Ranked 369 in June 2010 Top500 ranking). hpc Cluster II: 15,360 cores, 98TB RAM, Peak rating 316 Tflops (Ranked 130 in Nov 2013 Top500 ranking).
The Department organizes a yearly "JagadishwarMahanty Distinguished Lecture" (since the year 2005) by an eminent scientist which provides unique opportunity of interaction with faculty and students, and a "Research Scholars Day" involving short talks and poster presentations by research scholars in the department apart from the weekly colloquium and seminars.

FACULTY LIST

- **Adhip Agarwala,** Ph.D. Indian Institute of Science,Bengaluru 2018
  Areas of Interest: Theoretical quantum condensed matter physics
- **Aditya Kelkar,** Ph.D. Tata Institute of Fundamental Research, 2009
  Area of research: Experimental atomic collision physics, heavy ions and electron collisions, accelerator physics
- **Anjan Kumar Gupta,** Ph.D. University of Kentucky, 2001
  Area of research: Scanning Tunneling Microscopy, Superconductivity
- **Amit Agarwal,** Ph.D. Indian Institute of Science, Bangalore, 2009
  Area of research: quantum many-body effects, low-dimensional quantum systems
- **Anand Kumar Jha,** Ph.D. University of Rochester, 2009
  Area of research: Quantum-optics
- **Arjun Bagchi,** Ph.D. Harish chandra Research Institute, 2009
  Area of research: Theoretical High Energy Physics, String Theory
- **Arijit Kundu,** Ph.D. Heinrich-Heine University, Germany, 2012
- Area of research: Equilibrium and non-equilibrium quantum transport. Topological systems in condensed matter.
- **Asima Pradhan,** Ph.D. City University of New York, 1991
  Area of research: Medical Applications of Lasers
- **Avinash Singh,** Ph.D. University of Illinois at Urbana-Champaign, 1987
  Area of research: Strongly-correlated Systems
- **Apratim Kaviraj,** Ph.D, IISc Bangalore, 2017
  Area of research: Theoretical high energy physics, conformal field theories, critical phenomena
- **Chanchal Sow,** Ph.D. Indian Institute of Science, Bangalore, 2014
  Area of research: Magnetism in Complex Oxides, Interplay between Ferromagnetism and Superconductivity, Single Crystal and Thin Film Growth of Novel Quantum Materials, Strongly Correlated Electron Systems under Non Equilibrium Steady State (SCESness).
- **Chandrima Banerjee,** Ph.D. S N Bose Center, 2017
  Area of research: Experimental Condensed Matter Physics, Magneto-Optic Spectroscopy, Ultrafast Light Matter Interaction, XUV Spectroscopy
- **Debtosh Chowdhury,** Ph.D. IISc, Bangalore, 2013
  Area of research: Theoretical Particle Physics, Beyond the Standard Model phenomenology, Cosmology and Astroparticle physics
- **Dipankar Chakrabarti (HoD),** Ph.D. Saha Institute of Nuclear Physics, 2004
  Area of research: Quantum Chromodynamics, Lattice Gauge Theory, Lightcone Field Theories
- **Diptarka Das,** Ph.D. University of Kentucky, 2014
  Area of research: Conformal field theories, Non-equilibrium physics, String theory
- **Gautam Sengupta,** Ph.D. Institute of Physics, Bhubaneswar, 1992
  Area of research: String Theory & Quantum Gravity
- **Gopal Hazra,** Ph.D. Indian Institute of Science,Bengaluru 2018
  Areas of Interest: Astrophysical Magnetic fields, Exoplanets, Exoplanetary Atmospheres, Solar and Planetary winds, Space weather
- **Harshwardhan Wanare**, Ph.D. University of Hyderabad, 1998
  Area of research: Non-linear optics, imaging

FACULTY LIST

- **Jayita Nayak,** Ph.D. Devi AhilyaViswavidyalaya, Indore, 2015
  Area of research: Angle resolved photoemission spectroscopy of topological insulators, high Tc superconductors, and hard X-ray photoelectron spectroscopy of quasicrystals and Heusler alloys
- **Joydeep Chakrabortty,** Ph.D. Harishchandra Research Institute, 2011
  Area of research: Particle Physics (Theory and Phenomenology);
  Main interest: Unification of fundamental forces, Supersymmetry, Supergravity
- **K P Rajeev,** Ph.D. Indian Institute of Science, Bangalore, 1992
  Area of research: Low Temperature Physics
- **Kaushik Bhattacharya,** Ph.D. Saha Institute of Nuclear Physics, 2005
  Area of research: Cosmology, Particle Physics
- **Krishnacharya,** Ph.D. Max Planck Institute, 2007
  Area of research: Soft Matter Physics
- **Koushik Pal,** Ph.D, JNCASR, 2017
- Area of research: Materials theory and simulation, Materials informatics and machine learning, Quantum and energy materials
- **Mahendra K Verma,** Ph.D. University of Maryland, 1994
  Area of research: Nonlinear Physics, Turbulence, Nonequilibrium Statistical Physics, Astrophysics
- **Manas Khan,** Ph.D. Indian Institute of Science, Bangalore, 2011
  Area of research: Statistical Physics of Soft and Active Matter (Experiment, Modeling and Computation), Optical Trapping and Micromanipulation, Brownian dynamics simulation
- **Manoj Kumar Harbola,** Ph.D. City University of New York, 1989
  Area of research: Atomic and Molecular Physics
- **Navaneeth Poonthottathil,** Ph.D., Cochin University of Science and Technology (CUSAT) and Fermilab, 2017
  Area of research: Experimental High Energy Physics
- **Nilay Kundu,** Ph.D. Tata Institute of Fundamental Research, 2014
  Area of research: Theoretical High Energy Physics, String Theory
- **R Vijaya,** Ph.D. IIT Madras, 1991
  Area of research: Fiber optics, Nonlinear optics and Photonic band gap structures
- **Rajeev Gupta,** Ph.D. Indian Institute of Science, 2001
  Area of research: Optical spectroscopy and phases
- **Rohit Medwal,** Ph.D., University of Delhi, 2014
  Areas of Interest: Nanomagnetism, Spin transport and high frequency spin dynamics in spin devices, Terahertz spintronics
- **S A Ramakrishna,** Ph.D. Raman Research Institute, 2001
  Area of research: Photonics & Waves in Random Media
- **Sagar Chakraborty,** Ph.D. S N Bose National Centre for Basic Sciences, 2009
  Area of research: Nonlinear Dynamics, Evolutionary Game Theory
- **Saikat Ghosh,** Ph.D. Cornell University, 2008
  Area of research: Quantum Optics
- **Satyajit Banerjee,** Ph.D. Tata Institute of Fundamental Research, 2000
  Area of research: Superconductivity, Magneto-optics
- **Saurabh Mani Tripathi,** Ph.D. IIT Delhi 2010
  Area of research: Fiber and Integrated Optics

FACULTY LIST

- **Sivasurendar Chandran,** Ph.D. Indian Institute of Science, Bangalore, 2014
  Area of research: Polymer and Soft Matter Physics
- **Soumik Mukhopadhyay,** Ph.D. Saha Institute of Nuclear Physics, 2009
  Area of research: Spintronics, Nanomagnetism, Physics of complex oxide materials
- **Sudeep Bhattacharjee,** Ph.D. RIKEN, Japan, 1999
  Area of research: Plasma Physics, Focused ion beams from intense plasmas, Interaction of multi-element ion beams with matter, Physics of nano-scale systems
- **Sudeep K Ghosh,** Ph.D., Indian Institute of Science Bangalore, 2017
  Areas of Interest: Superconductivity and magnetism, Topological order, Ultracold atoms
- **Sapam Ranjita Chanu,** Ph.D., Indian Institute of Science Bangalore, 2014
  Areas of Interest: Quantum computation and simulations with cold ions, cold atoms and quantum metrology with single pure state of cold atoms and ions
- **Sabyasachi Chakraborty,** Ph.D., IACS, Kolkata, 2016
  Areas of Interest: Theoretical Particle Physics
- **Sudipta Dubey,** Ph.D. Tata Institute of Fundamental Research, 2015
  Area of research: Opto-electronics, Physics of atomically thin materials, Low-temperature electrical transport
- **Supratik Banerjee,** Ph.D.Universite Paris-Sud, France 2014
  Area of research: Turbulence in fluids, Physics of space and astrophysical plasmas
- **Swagata Mukherjee,** Ph.D., University of Calcutta, 2016
  Area of research: Experimental High Energy Physics, Collider experiments.
- **Sanmay Ganguly,** Ph.D, TIFR, Mumbai, 2015
  Area of research: Experimental High Energy Physics, Application of machine learning in HEP and other branches of physics
- **Taraknath Mandal,** Ph.D., IISc, Bangalore, 2015
  Area of Research: Computational Soft Matter Physics and Biophysics
- **Tarun Kanti Ghosh,** Ph.D. Institute of Mathematical Sciences, 2003
  Area of research: Utra-cold atomic gases, Nanoscopic physics
- **Tapobrata Sarkar,** Ph.D. Institute of Mathematical Sciences, 2001
  Area of research: String Theory & Quantum Gravity
- **Venkata Jayasurya Yallapragada,** Ph.D., TIFR, 2017
  Area of research: Nanophotonics, nanoscale light emitters and scatterers, biogenic photonic structures, optical imaging
- **Y N Mohapatra,** Ph.D. Indian Institute of Science, Bangalore, 1989
  Area of research: Semiconductor Physics, Material Science
- **Zakir Hossain,** Ph.D. Tata Institute of Fundamental Research, 1997
  Area of research: Superconductivity, Strongly-correlated electron systems

BROAD RESEARCH AREAS

The major research groups and active research areas are listed below:

Condensed Matter Experiments

- Magneto-Optical Imaging
- Nanostructures of Superconducting and Magnetic Materials
- Intense Laser-Matter Interaction
- Non-Equilibrium Transitions in Driven Vortex States of Superconductors
- Interplay between Magnetism and Superconductivity
- Magnetic and Transport behaviour of Heavy Fermion Compounds
- Electronic, Magnetic, Optical Properties of Surfaces using Scanning Probe Microscopy
- Electronic and Magnetic Properties of Transition Metal Oxides
- Charge Ordered State of Transition Metal Oxide Thin Films
- Spintronics, Spin-Polarized Tunneling in Transition Metal Oxides
- Strongly Correlated Electron Systems in Low Dimensions
- Photonic and Electronic Materials
- Printable Electronics, Organic LED and Lighting
- Defects and Disorder in Semiconductors
- Effects of Localized States on Electrical and Optical Properties
- Hybrid Inorganic/Organic Devices
- Amorphous and Porous Silicon
- Electronic Properties of Crystalline Semiconductors
- Dielectric spectroscopy
- Broadband FMR spectroscopy, spin pumping
- Spin transport,Inverse Spin Hall Effect
- Low dimensional magnets
- Soft Matter Physics

Condensed Matter Theory

- Electronic Structure of Disordered Systems
- Molecular Dynamics Simulations and Genetic Algorithms
- Topological Insulators
- Applications of Density Functional Theory
- Electronic Structure of Atoms, Molecules, and Solids
- Correlated Electrons and Quantum Magnetism
- Spin, Charge, Orbital Correlations in Transition Metal Oxides
- Antiferromagnetism, Superconductivity, BE Condensation and Disordered Systems
- Low Dimensional Electronic Systems, Graphene, Spintronics
- Quantum Many Body Effects in Low Dimensional Systems
- Transport Properties of Hybrid Structures
- One-Dimensional and Quasi-One Dimensional Spin and Electron Systems
- Classical and Quantum Phase Transitions in Random Systems
- Non-Equilibrium Dynamics of Magnetic and Non-Magnetic Systems
- Statistical and Theoretical Biophysics
- Natural Nano Machines, Complex Adaptive Biological networks
- Driven-Dissipative Systems, Self-Assembled Soft and Bio-Materials
- Phase Transitions in Driven Diffusive Systems
- Non-equilibrium Dynamics of Spin Systems

BROAD RESEARCH AREAS

- Physics of Biopolymers and Molecular Motors
- Nonlinear Dynamics, Fluid Dynamics, Turbulence
- Magnetohydrodynamics, Turbulence, and Dynamo
- Structured Photonic Materials and Negative Refractive Materials
- Plasmonic Properties of Metallic Structures
- Quantum Entanglement and Quantum Computation

Photonics and Quantum Optics

- Laser Raman Spectroscopy
- Laser-Plasma Studies
- Bio-Medical Applications
- Nonlinear Optics, Fiber Optics
- Photonic Band Gap Structures
- Imaging in Complex Media & Biological Tissues
- Photonics and Waves in Random Media
- Coherent Control of Light-Matter Interaction
- Non-Linear Optics, Quantum Optics
- Quantum Optics, Quantum Information, Precision Spectroscopy
- Cold-Atom Systems, Foundations of Quantum Mechanics
- Using Cold-Atom Systems to Probe Nano-Materials and Molecules.

High-Energy Physics

- Quantum Field Theory
- Astrophysics, Cosmology, Astroparticle Physics
- Particle Physics, Beyond Standard Model Phenomenology
- Quantum Chromodynamics, Lattice Gauge Theory
- Classical and Quantum Gravity,
- String Theory, AdS-CFT and AdS-Condensed Matter correspondence.
- Black Holes Thermodynamics.
- Hydrodynamics from charged black branes, fluid dynamics and gravity
- Experimental High Energy Physics (Neutrino Experiments and Collider Physics Experiments)

Plasma Physics and Ion beam Physics

- Experimental plasma physics
- Wave Interaction with plasmas confined in multi-cusp magnetic fields
- Physics of plasmas confined by a dipole magnet
- Atomically heterogeneous systems created with low energy ion beams
- Atmospheric pressure low temperature micro-plasmas
- Plasma based multielement focused ion beams
- Research using focused ion beams
- Ion-Beams for science, engineering and technology

Complex Systems

- Biological and Statistical Physics
- Statistical physics of Soft and Active matters
- Optical Tweezers and Micromanipulations
- Brownian dynamics simulations

BROAD RESEARCH AREAS

- Nonequilibrium statistical physics
- Analytical theory for different type of turbulent flows
- Turbulence in living fluids
- Exoplanets
- Origin of magnetic fields in the Sun and stars
- Star-planet interaction and space weather
- Nonlinear Dynamics
- Evolutionary Game Theory
- Computational Soft Matter Physics and Biophysics
- Soft Condensed Material
- Smart Surfaces with Tuneable Wetting Properties
- Soft Condensed Matter
- Surfaces and Interfaces
- Biological Fluids
- Turbulence and Nonlinear Dynamics,
- High Performance Computing
- Experimental Plasma Physics
- Focused Ion Beams
- Physics of Nanoscale Systems

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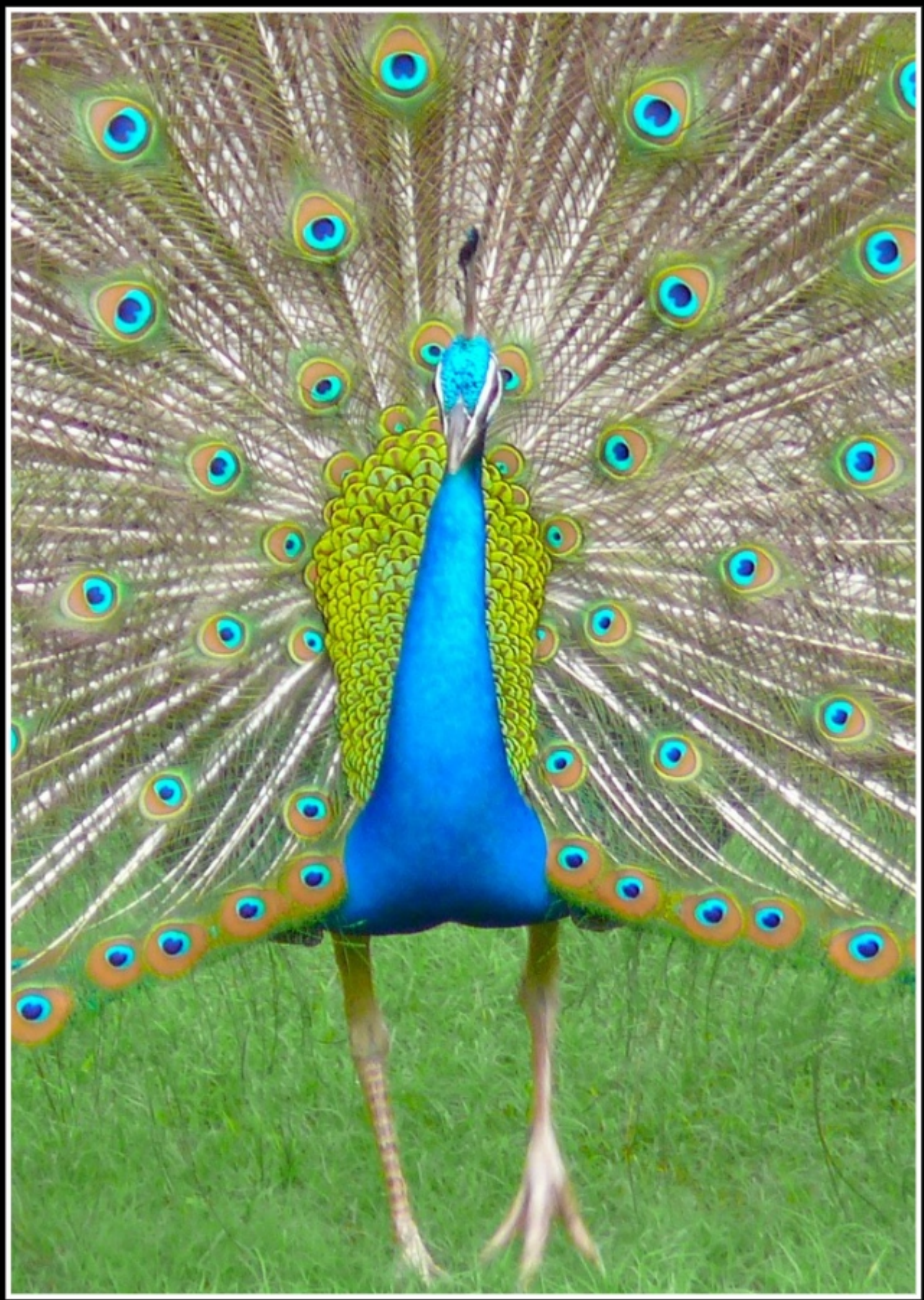


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