Application For Summer Internship in Theoretical Condensed Matter Physics

Amey Gaikwad

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I am Amey Gaikwad. I am a third year undergraduate studying Engineering Physics with a minor in Mathematics at the Indian Institute of Technology. Currently I stand second in my college among a batch of 900 students and have also received the Institute Academic Award in 2015-2016. I wish to apply for the Summer Internship program to be organised at the Max Planck Institute for the Physics of Complex Systems organised by the Department of Condensed Matter Physics in the summer of 2018. I believe that this internship would give me an opportunity to interact with the Condensed Matter community at the Max Planck Institute which would further my interest in this field.

My first research experience was in the winter of 2016. It gave me an idea that the real world problems are much more complicated to be solved exactly. I worked on a numerical project under Prof. Neela Nataraj. My interest in theoretical physics began to develop when I spent the summer of 2017 at the International Centre Of Theoretical Sciences (ICTS-TIFR), Bangalore as a part of the SN Bhatt Memorial Excellence Fellowship Program. I was assigned to work with Dr. Pallab Basu. During the course of 8 weeks, I got a brief glimpse of the research going on in theoretical physics. I used to give regular presentations regarding the work I was doing. I also got a chance to interact with the members of the Condensed Matter group and attend their talks. I was also able to appreciate the applications of Condensed Matter Physics to other branches of theoretical physics. As a follow up to the work I had done in the summers, I took a course in Quantum Field Theory under the guidance of Dr.Loganayagam and Prof. Ramadevi. I will be taking a course in Condensed Matter in my next semester where I hope to put my past research experiences and courses taken to good use in order to appreciate it better.

Currently my interests lie in understanding the applications of Quantum Field theory. I am interested in Open Quantum Systems, Entanglement, Topological Insulators and Superconductivity. I am also interested in the Schwinger Keldysh path integrals and their applications for understanding Finite temperature quantum field theories. Recently I have also explored papers which relate the holographic principle to superconductors.

Through the summer internship, I aim to experience a very good research/learning opportunity at the Max Planck Institute which is reputed for its research in the-

oretical Condensed Matter Physics..This would also broaden my horizons and give me a firsthand training in the areas of my interest. As a continuation to the courses I have undertaken and my past research experiences, I hope to explore the frontiers of theoretical Condensed Matter physics and see how it connects to other interesting areas of physics.

The Resume following the cover letter hopes to expand the information about the courses I have done and the work I did in the first three years of college.

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Examination	University	Institute	Year	CPI / %
Graduation	IIT Bombay	IIT Bombay	2020	9.83
Intermediate/+2	MUMBAI UNIVERSITY	PACE JUNIOR SCIENCE COLLEGE , NERUL	2015	94.92
Matriculation	ICSE, Delhi	RYAN INTERNATIONAL SCHOOL , KHARGHAR	2013	96.70

FIELDS OF INTEREST

- Quantum field theory, Theoretical Condensed Matter Physics, String theory, Mathematical physics, Cosmology

TECHNICAL SKILLS

- **Languages** : C++, Java, Python, VHDL
- **Tools** : Mathematica, LaTeX, OriginPro, MATLAB, Gravipy, Numpy, Scipy, Arduino, FPGA
- **Key Courses**: Special and General Relativity, Classical and Quantum Mechanics, General Topology, Differential equations, Real, Complex and Numerical Analysis, Basic Algebra (Ongoing), Group theory Methods in Physics (Ongoing), Relativistic Quantum mechanics (Ongoing) and Quantum Field Theory (Ongoing)

MAJOR PROJECTS

- **Quantum Field Theory** (EP 322 Supervised Learning Project)
  (Guide: Dr. R. Loganayagam (ICTS-TIFR - String Group) and Coguide: P. Ramadevi (Department of Physics , IITB) , Autumn 2017-2018 (Ongoing))
  - Path Integral Formulation of Quantum Mechanics.
  - Zero and one dimensional quantum field theory.
  - Schwinger Dyson equation, Perturbation Theory, Symmetry factors and Feynmann Diagrams.
  - Scattering matrix through the path integral formalism.
  - Basics of Grassmanian algebra, and representation of Lorentz group.
- **Instantons, Monopoles and Solitons in Non Abelian Gauge theories** (ICTS SN Bhatt Memorial Excellence Fellowship Program)
  (Guide: Dr. Pallab Basu (ICTS-TIFR - String Group) , Summer 2017)
  - Confinement: Instantons, solitons and monopoles in Non Abelian gauge theories.
  - Instantons of the double well potential and in the Yang-Mills theory.
  - Symmetry breaking (Goldstone theorem) and Higgs mechanism.
  - Polykov monopole and the BPST monopole via the Bogomol'nyi bound.
  - Report: https://github.com/ameypg16/Reports/blob/master/Amey-Report-SNBhatt.pdf.
- **Multistablity of planar bistable liquid crystals** (National Program on Differential Equations(NPDE))
  (Guide: Prof. Neela Nataraj (HOD: Department of Mathematics,IITB) , Winter 2016)
  - Finite Elements Method and the Newton Galerkin approximation to analyse what drives the normal bistable liquid crystals into multistability.
  - Analysis done using the Landau de Gennes free energy frmaework for the liquid crystals.
  - Report: https://github.com/ameypg16/Reports/blob/master/NPDE-report.pdf
  - Code files: https://github.com/ameypg16/NPDE-Final-D1.
- **Music Synthesis** (EP 226 - Waves,Oscillations and Optics)
  (Guide: Prof. Tapanendu Kundu (Department of Physics,IITB) , Spring 2016-17)

- Developed a code to tailor a song from the bare essentials - the frequency of the notes/chords involved and the duration.
- Appropriate ADSRs were chosen depending on the instrument and the scenario being mimicked.
- Report:
  https://github.com/ameypg16/Reports/blob/master/music-synthesis-report.pdf

- **3 Body Collider Simulation** (EP 230 Electronics Lab - Digital Systems)
  (Guide: Prof. Pradip Sarin (Department of Physics,IITB) , Spring 2016-17)
  - Developed a code in VHDL using an FPGA board to simulate an animation involving 3 bodies.
  - The bodies were coded to bounce off each other and off the walls delimited by the VGA monitor.
  - Project Report :
    https://github.com/ameypg16/Reports/blob/master/FPGA_project_3_body_collision.pdf

- **Chaos in Cryptography** (PH 542 Non Linear Dynamics)
  (Guide: Prof. Amitabha Nandi (Department of Physics,IITB) , Autumn 2016-17)
  - Analyzed the topological similarities between cryptography and chaos theory and how chaos can be used in cryptography.
  - Used the Baptista algorithm and chaotic maps were developed on the basis of the logistic map and Lorenz's dynamical model.
  - Project Presentation: https://github.com/ameypg16/Reports/blob/master/NLDproject.pdf

ACADEMIC ACHIEVEMENTS

- Ranked **second in the institute among a batch of 900 students** for the academic years 2015 - 2016 and 2016-2017.
- **Topper in the Physics Department** for the academic years 2015-16 and 2016-17.
- Ranked **first** in the Physics Department in the academic year 2015-2016.
- **Awarded the Institute Academic Award** by IIT Bombay for the year 2015-16 (**3rd in the Institute** - CPI-9.94)
- Secured an **SPI of 10.0** in the first semester 2015-16.
- Awarded **AP** grade for Calculus and Numerical Analysis.
- **2015** : Topper in Maharashtra Board in **Physics** (100/100) and **Electrical Maintenance** (200/200)
- **2014-15** : **National Top 1% in NSEP** (Physics).
- **2014-15** : **National Top 1% in NSEA** (Astronomy).
- **2015** : Offered admission to **CMI, ISI, and IISc**.

SCHOLARSHIPS

- **2015** : Awarded eligibility for **INSPIRE Scholarship** (by qualifying within top 1% of Maharashtra board at class XII – March 2015)
- **2013** : Kishore Vigyan Protsahan Yojana **(KVPY)** awarded by Department of Science and Technology, India for promotion of basic sciences among high school students.
- **2011-2012** : National Talent Search Scholarship **NTSE** awarded by the National Council for Educational Research and Training.

RESUME AND REPORTS

- Resume : https://github.com/ameypg16/CV
- Reports : https://github.com/ameypg16/Reports