Pushkar Mohile

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I am an undergraduate student in the department of Physics at IIT Bombay looking for a Ph.D. program. My research interests revolve around theoretical and mathematical physics. In particular, I am interested in integrability in Physics and QFT.

Education

Year	Program	CGPA/%	Institute
2022(ongoing)	B.Tech. Engineering Physics (Hons.)	9.81	IIT Bombay
2018	Intermediate/+2	92.92%	Maharashtra HSC, India
2016	Matriculation	10	CBSE, India

Research Experience

Thermodynamic Bethe Ansatz, Resurgence Theory and Integrability

May 2021-Present — *Bachelor's Thesis Project, Guide: Prof P Ramadevi, Dept. of Physics, IITB*

- Studied the Bethe ansatz for integrable spin chains and the connections to quantum mechanics via the correspondence between Ordinary Differential equations and Integrable models (ODE/IM)
- Formulated a Bethe-like ansatz for the hydrogen atom with angular momentum terms, obtaining a set of Bethe equations for the roots of the Laguerre polynomials.
- Studying the exact WKB method from resurgent quantum mechanics and the thermodynamic Bethe ansatz (TBA) system to attempt to extend the Bethe-like ansatz to other potentials.
- Currently working to extend the TBA system to potentials with singularities in the derivatives.

Comparing Extinction in Deterministic and Stochastic Population Models

May-Jul 2019 — *Guide: Prof Chetan Gadgil, CEPD National Chemical Laboratory*

- Performed a literature survey of mathematical models used to represent interacting populations showing inter-species and intra-species competition, cyclic dominance and harvesting.
- Studied analytical and numerical techniques for analyzing extinction in population models.
- Built and simulated these deterministic models and their stochastic analogues in MATLAB using SimBiology to show that extinction is favoured more in stochastic models.

Key Projects

Joyal Species in perturbative QFT

Mar-2020 Current — *Advisor: Prof William Norledge, Penn State University*

- Studied perturbative Algebraic Quantum Field Theory. Read about the algebraic formulation of key constructions in perturbative QFT like the S-matrix.
- Reviewed the combinatorial properties of the time ordered product via the Species-theoretic formulation. Currently looking for similar species-theoretic properties in the quantum Calogero-Moser model.

Solitons, Integrable Systems , Infinite Dimensional Algebras

Jul - Dec 2020 · *PH303 Supervised Learning Project. Guide: Prof UA Yajnik, Dept. of Physics, IITB*

- Studied the kink and soliton solutions in the ϕ^4 model, sine-Gordan system in 1+1 dimensions and $O(3)$ Ferromagnet in 2+1 dimensions, and the topological charges present in this system.
- Reviewed the inverse scattering method and the lax pair formalism as a method for finding the time evolution of classical integrable systems in 1+1 dimensions such as the Korteweg–de Vries (K-dV) equation and the conservation laws arising from the monodromy matrix in these cases.
- Explored the connection between the K-dV equation and Conformal Field Theory through the infinite dimensional affine Lie algebras generating symmetries in the K-dV equation and the Virasoro algebra using the Sugawara construction.

Topological Nature of Nonlinear Optics

Sep - Nov 2020 · *PH404 Photonics Course Project. Guide: Prof Anshuman Kumar, Dept. of Physics, IITB*

- Worked in a team of 4 to reproduce the results in the paper "Topological Nature of Nonlinear Optics in Solids" by Morimoto and Nagaosa.
- Studied the Keldysh and Keldysh-Floquet formalism for nonequilibrium Quantum Field Theory in crystals and its use in calculating currents for light matter interaction using the Keldysh Green's functions.

Solitons as energy carriers in 1-D FPUT Lattices

Spring 2020 · *PH202 Waves and Optics. Guide: Prof Anshuman Kumar, Dept. of Physics, IITB*

- Worked in a team of 4 to reproduce the calculations in the 2018 paper "Solitons as candidates for energy carriers in Fermi-Pasta-Ulam lattices". that shows *sech* and *sech*^{2} type solitons are viable energy carriers in $\alpha\beta$ type FPUT lattices where phonon normalization isn't accurate.
- Used Mathematica for performing analytical calculations and Matlab for simulating FPUT lattices in order to extract predictions for sound velocity based on multiple parameters like Temperature and α or β.

Ardio - Model for realtime audio processing on low power embedded systems

Fall 2020 · *PH230 Digital Electronics Lab Course Project. Guide: Prof Pradeep Sarin, Dept. of Physics*

- Developed an optimized Fourier Transform algorithm capable of working on low power devices such as an Arduino whilst retaining reasonable accuracy.
- Demonstrated frequency finding on live audio samples in near real-time on an Arduino Uno with less than 2KB RAM.

Simulating Tetris using Verilog and SDL2

Spring 2020 · *PH230 Digital Electronics Lab Course Project. Guide: Prof Pradeep Sarin, Dept. of Physics*

- Worked in a team of 2 to design and simulate the game of Tetris. Used Verilog to make a state machine and SDL2 with OpenGL and a C++ wrapper to handle Input/Output.
- Created a 10×20 board with transitions based on the inputs which would move the active tetrimino and delete rows and update the score when the tetrimino could no longer move.

Talks given

Gravity in Anti de Sitter space

October 2021 *Course seminar: PH807 Advanced Topics in Physics Instructor Prof. UA Yajnik*

- Gave a 90 minute lecture on the properties of Anti-de Sitter space, motivating the AdS/CFT correspondence.
- Discussed the definition and isometry group of $p-$dimensional AdS space, coordinate patches, geodesics and closed timelike curves (CTCs) on the space. Presented the conformal boundary of AdS space and the equality between the conformal group on Minkowski space and isometry group of AdS space.

Teaching Experience

August-
November
2019

Teaching Assistant, Quantum Physics and its Application

- Conducted weekly tutorial classes for a batch of 46 1st Year Students for introductory quantum physics course
- Solved problems and held doubt clearing sessions while being regularly available to help students outside class hours.

Academic Achievements

2019-2020 Department Rank 2 out of 45 in batch of 2022 Engineering Physics

2018-2020 **Institute Academic Award** — Awarded to the top academic performers in the department

2018 Scored in the 99.63^{th} percentile in the JEE Advanced out of 220,000 candidates

2018 Scored in the 99.95^{th} percentile the in JEE Mains out of 1,000,000 Candidates

2017 Achieved a rank of 124 among 1000 selected candidates for Kishore Vaigyanik Prothsahan Yogna (KVPY) Scholarship for basic sciences by the Dept of Science and Technology, Gov. of India

2018 Top 1 Percent in Maharashtra in Class 12 HSC Exam and eligible for INSPIRE Scholarship

2017 **Indian National Chemistry Olympiad**— Ranked in the top 1% out of 55,000 + students of the National Standard Examination in Chemistry and participated in the INChO exam

Fall 2019 **AP Grade in Differential Equations 2**— Awarded to top 1% of the course participants

Key Courses

Physics: Special Topics in Elementary Particle Physics*, Quantum Information and Computing*, Quantum Mechanics, Advanced Quantum mechanics(QM2) and Relativistic quantum mechanics(QM3),Advanced Topics in General Relativity, General Theory of Relativity, Special Theory of Relativity, Classical Mechanics, Thermal Physics

Maths: Combinatorics 2* , Algebraic Topology*, Differential Geometry, Finite Semigroup Theory:Bimonoids and bialgebras in species, Topics in algebra 2:Introduction to Category Theory and Representation Theory of Hyperplane arrangements, Complex analysis and Multivariable Calculus,

Labs: General Physics, Chemistry, Introduction to Electronics, Op-Amp Circuits, Digital Circuits, Solid State physics, Nuclear physics, Optics and Spectroscopy

* Ongoing Courses not listed in transcript

Extracurricular Activities

December
2020

Open Quarterfinalist, United Asians Debating Championship,reaching the top 8 out of 100+ teams across Asia.

October 2020 Open Semifinalist, Asian British Parliamentary Debate, reaching the top 8 out of 160+ teams across Asia.

July 2020 Open Octofinalist, Australasian Intervarsity Debate Championship, reaching the top 16 out of 130+ teams from all over Asia and Australia.