Kartik Patekar

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Education

IITB (Indian Institute of Technology, Bombay) — *CGPA : 9.90/10*

Third Year Undergraduate — *Aug. 2016 - Present*

- Major : Engineering Physics with Honors
- Minor : Mathematics

CBSE (Central Board of Secondary Education) — *Percentage : 91.2*

Intermediate/+2 — *July 2015 - Mar. 2016*

Research Contributions

- **The role of system–meter entanglement in controlling the resolution and decoherence of quantum measurements.** *New Journal of Physics*, 21(10):103006, oct 2019.
  Published my research with Professor Holger Hofmann on how the system-meter entanglement and the choice of the the readout basis affect a quantum measurement.
  The research article can be accessed by clicking on this link.

Key Projects

Gauge Theory of Doped Cuprates

Report URL

Guide: Professor Subir Sachdev, Harvard University — *May. 2019-July 2019*

- Worked on Gauge Theory developed by Professor Sachdev to describe the phase diagram of doped cuprates. Used the strong coupling expansion to obtain effective Lagrangian describing the system.
- Used the saddle point approximation in the limit of large number of Higgs Flavors to obtain the phase diagram by exploiting the symmetry of the system. Analytically solved the saddle point equations to obtain the disordered, topological and trivially ordered phases.
- Supported the results obtained in the saddle point limit by Monte Carlo simulation performed on physical case of four Higgs Flavor. Established the existence of the Topological phase.
- Separately, I also studied the SYK model and attempted to obtain a **symmetry breaking transition** to pair 2 different species of complex fermions in an **SYK-like model**.

Quantum Chaos in Many body systems

Report URL

Guide: Professor Subir Sachdev, Harvard University — *Aug. 2019-Present*

- Reviewed and reproduced the calculation of lyapunov exponent for ϕ^4 model of Hermitian matrix field in the weak coupling limit done by Douglas Stanford (doi:10.1007/JHEP10(2016)009). Evaluated the ladder diagrams to obtain the eigenvalue equation and calculated the largest lyapunov exponent.
- Studied the behavior of Quantum many-body chaotic systems and the it's diagnosis using the Out-of-time-order correlators.
- Analyzed the random Matrix Theory of the Gaussian Unitary Ensemble to obtain the spectrum, n-point correlation function and the spectral form factor.
- Separately, I also studied the SYK model and attempted to obtain a **symmetry breaking transition** to pair 2 different species of complex fermions in an **SYK-like model**.

Quantum Measurement at Variable Strength

Report URL

Guide: Professor Holger F. Hofmann, Hiroshima University — *Dec. 2018*

- Quantified the **resolution** of the measurement and explained **physical importance** of it. Showed how the resolution relates to the **amount of back action** caused due to interaction.
- Analysed the role of entanglement in **determination of the measurement strength** and precision.
- Studied the **Arthurs-Kelly** joint measurment scheme and analysed the joint measurement of two non-commuting observables.
- Analysed the importance of **meter readout basis** in determining the information extraction of system and reversing the back action, and detailed the procedure to find the optimal read out basis.

Superconducting Quantum Circuits

Report URL

Guide: Professor Steven Girvin, Yale University *May. 2018 - July 2018*

- Studied the Theory of **Circuit Quantization** and applied it to various circuit. Realised about **Uncoupled modes** as mentioned in Chapter 2 of report.
- Understood the **theory of Transmission line** and **Input output theory**, both in **Classical** as well as **Quantum case**. Also, studied the theory of **Amplification using Transmission line and negative resistance**.
- Studied about **3 wave mixing circuits** and devised a simple circuit for three wave mixing which can be solved analytically.
- Read about **Coherent States** and understood its importance in Quantum Computing to obtain **Cat states**.
- Studied different superconducting qubits, namely **fluxonium qubit**, **Phase qubit** and **Charge qubit**.

Quantum Measurement Problem

Report URL

Guide: Professor T. P. Singh, Tata Institute of Fundamental Research *Dec. 2017 - Mar. 2018*

- Studied various collapse model including **QMSL** and **CSL** models.
- Read about a Collapse model proposed recently by ”Apoorva Patel” and ”Parveen Kumar” and Compared it with standard collapse models.
- Read the theory of **Open Systems** and derivation of Lindblad equation under Markovian Approximation.
- Read about restrictions imposed by impossibility of **Superluminal Signalling** and understood **Gissin Theorem**
- Also studied **Stochastic calculus** and integration of SDE in **ito form** and **stratonovich form**.

Silicon detector Calibraton

Report URL

Guide: Professor Pradeep Sarin, Physics Department, IIT-B *Apr. 2017 - Jul. 2017*

- Designed and fabricated a high precision **low time-period pulse Generator** for use in calibration of Detector readout systems.
- Converted the voltage pulse into **current pulse** using an **Operational Transconductance Amplifier**.
- Minimised the reflection in the device through impedence matching
- Understood and tested **Signal Transmission and Reflection** in Coaxial Cables.

Terminating Tether

for ADVITIY-Second Generation Satellite of IIT-B *Jan. 2017 - Feb. 2017*

- Worked on developing a **de-orbiting mechanism** of student satellite using tether system which operates on electromagnetic principles.
- Studied the effects of ionosphere on a moving bare metal strip.
- **Simulated** motion of Satellite using MATLAB.
- Studied in details about **thermionic electron emitters**, **hollow cathode emitters** and **field emitters**.

Course Projects

Dielectric Function, Screening and Plasmons for Graphene

Report URL

Guide: Professor Hridis Pal, Physics Department, IIT-B *Nov. 2019*

- Studied the various properties of Graphene and contrasted them with the properties of normal 2D materials with quadratic dispersion relations.
- Reproduced the derivation of **Polarization function** of Graphene to separately consider the interband and intraband transitions. Obtained the **static dielectric function** and separated the contributions of intrinsic and extrinsic charge carriers.
- Studied and presented the paper **(DOI: 10.1103/PhysRevB.75.205418)** to the course instructor.
- Worked out the **dispersion relations for plasmons** for monolayer and bilayer graphene and compared their dependence on charge carrier density with normal 2D materials.

Dimer Model

Report URL

Guide: Professor Sumiran Pujari, Physics Department, IIT-B *Aug. 2018 - Nov. 2018*

- Studied the exact solution of dimer model using **Kasteleyn theory**. Looked at the extension of Kasteleyn theory for the case of **periodic boundary conditions**.
- Analysed the variation of **probability** of occurrence of a dimer on the lattice edges using **perturbation theory** and **computational methods**. Also analysed the effect of emergence of **long distance interaction** from nearest neighbour interaction.
- Studied the solution of dimer model using **mean-field theory** and compared the result with exact solution.
- Understood **height representation** on the lattice and it’s relation with the continuum model obtained by coarse graining.

Chaos in Special Relativistic Dynamics

Guide: Professor Punit Parmananda, Physics Department, IIT-B *Sept. 2017*

- Studied the **relativistic analog of Euler’s three body problem** in case of Electrostatics.
- Understood **Relativistic Capture** using hamiltonian formalism.
- **Simulated** both Newtonian and Relativistic Version of the problem to visualise the difference between the two cases.
- Realized that the system shows **Transient Chaos** and plotted the phase space to observe the occurrence of **Fractional Attractor Basin Boundary**.

Gesture Mouse

Report URL

Guide: Professor Pradeep Sarin, Physics Department, IIT-B *Jul. 2018 - Nov. 2018*

- Made a wireless device which can **control the mouse pointer** of a computer using hand movements and gestures.
- Used the data obtained using **magnetometer HMC-5883l** to move the pointer. A sudden rotation of the device was used to implement left/right clicks. Added the functionality of "hold left mousebutton" to allow scrolling.
- Estabilished connection between **bluetooth HC-05** and python so that the device could **communicate wirelessly**.

Random Walker on FPGA

Guide: Professor Pradeep Sarin, Physics Department, IIT-B *Mar. 2018- Apr. 2018*

- Configured FPGA to simulate **300 random walkers** which moved a step with probability 0.5 on pressing a switch.
- Stored the position of each random walker on FPGA which was transferred to PC in real time to obtain the **statistics** of random walks.

Scholastic Achievements

IChO 2016 (International Chemistry Olympiad)

Aug. 2016

- Selected among the **four students** to **represent India at IChO 2016** held in **Tbilisi, Georgia.**
- Received **silver medal** for my performance in practical and theoretical exams.

IIT-B Academic Excellence Award

Aug. 2016-Mar. 2019

- Received **10/10 CGPA** and secured **Institute Rank 1** in IIT-Bombay in academic year 2016-2017. Have received the **Excellence Award** in subsequent years for **Department rank 1**.

IIT-JEE (Indian Institute of Technology - Joint Entrance Exam)

May. 2016

- Secured **All India Rank 6** amongst 200,000 students who appeared in the entrance exam for IIT.

KVPY (Kishore Vaigyanik Protsahan Yojana)

Feb. 2016

- KVPY is an on-going national program of **fellowship in basic sciences**, funded by Dept. of Science and Technology, Government of India, for highly motivated students.
- Obtained **All India Rank 5** in selection test for KVPY fellowship

Relevant Courses

- **Physics :** Elementary Particle Physics, Relativistic Quantum Mechanics, General Relativity, Quantum Mechanics I, Quantum Mechanics II, Condensed Matter Physics, Quantum Information and Computing, Electromagnetic Theory, Basics of electricity and magnetism, Statistical Physics, Thermal Physics, Photonics, Waves and Oscillations, Group Theory Methods, Non-Linear Dynamics.
- **Mathematics :**Topology, Real Analysis, Complex Analysis, Differential Equations, Numerical Analysis.
- **Electronics :** Digital Electroonics, Introduction to Electronics, Electronics Lab: Basic Circuits, Electronics Lab: Analog Circuits, Electronics Lab: Digital Circuits.
- **Others :** Computer Programming, Computer Networks, Data Structures and Algorithms, Data Analysis and Interpretation.

Technical Skills

- Familiar with **C, C++, Python and Mathematica**. Have also used **MatLab**, **OOMMP** and **COMSOL** for simulations.
- **Socket Programming** and **App Development**.
- Knowledge about **microcontrollers** such as AT-mega328. I have also used **Arduino** in some of my projects.
- Familiar with Eagle to **design circuit boards** with various types of components (Surface mount and Through hole).
- Experience with various electronic devices like GPS shield, bluetooth module, sensors and GPRS module.

Positions of Responsibility

Manager, Maths and Physics Club

IIT-Bombay *Apr. 2018 - Present*

- Leading a team of six to foster enthusiasm in Physics and Mathematics, tending to a community of over 500 on campus and an outreach of over 7000 online.
- Prepared questions and Handled Judges in Bazinga, an Institute wide quiz on Physics and Mathematics.
- Organised **group discussions** on various topics such as **Paradoxes in Physics** , Quantum entanglement.
- Administered lectures by notable researchers and professors in their field of interest.
- Conducted **Summer of Science**, an initiative to help students study their chosen topics during summers through the guidance of mentors assigned to them. More than 400 students participated in SoS-2018.

Organizer, Sixth Sense Workshop

Techfest, IIT-Bombay *Dec. 2016*

- Coordinated a **two day workshop** on robotics during IIT-B's annual technical festival.
- More than **250 people** attended the workshop from India and learnt about Image recognition and AVR coding

Extracurricular Activity

Adventure Activities

Aug-2016 - PRESENT

- Attended a 15 day **Mountaineering Adventure Course** in Jammu and Kashmir (India) organised by **Jawahar Institute of Mountaineering and Winter Sports.**
- Took part in a **5 day trek** in Himachal Pradesh, India during December, 2016.
- **Trekked** on Kalavanti Durg having elevation of 7300 meters. I have also camped overnight on several occasions.

Other Activities

- Attended 3-day **Vijyoshi Camp**, organised by **Indian Institute of Science**, where many leading researchers in various branches of Science and Mathematics gave lectures.
- Completed 80 hours of **Social Service** under Events department of **National Social Service**, and organised various events for upliftment of poor people.
- Selected in **Jigyasa**, an annual science quiz organised by Centre for Excellence in Basic sciences, Mumbai.
- Made a **Remote Controlled Bot**.
- Wrote a python code which can **detect and identify the constellations** present in a given photograph for **Python Hackathon** organised by Wwb and Coding Club-IITB, in which my team stood Second.