Kartik Patekar

Room 8078 - Hostel 18, IIT-Bombay, Mumbai, INDIA-400076.

(+91) 8356839624 | kartikpatekar@iitb.ac.in | kartikpatekar@gmail.com

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

- K. Patekar and H. F. Hofmann, **"The role of system–meter entanglement in controlling the resolution and decoherence of quantum measurements."** New Journal of Physics, 21(10):103006, oct 2019.
- H. D. Scammell, K. Patekar, M. S. Scheurer, and S. Sachdev, **"Phases of $SU(2)$ gauge theory with multiple adjoint Higgs fields in 2+1 dimensions."**(2019), arXiv:1912.06108 [cond-mat.str-el].

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 **Confining, topological and trivial Higgs phases**. The obtained results were supported by the Monte Carlo Simulations.
- 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 Gautam Mandal, Tata Institute of Fundamental Research — *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.

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.
- Studied different superconducting qubits, namely **fluxonium qubit**, **Phase qubit** and **Charge qubit**.

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.

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 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.

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.

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

Report URL

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

Technical Skills

- Familiar with **C, C++, Python and Mathematica**.
- **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.

Extracurricular Activity

- Completed **80 hours** of **Social Service** under **Events department of NSS (National Social Service)**, and organised various events for upliftment of poor people.
- Attended a 15 day **Mountaineering Adventure Course** in Jammu and Kashmir (India) organised by **Jawahar Institute of Mountaineering and Winter Sports.**
- Attended 3-day **Vijyoshi Camp**, organised by **Indian Institute of Science**, where many leading researchers in various branches of Science and Mathematics gave lectures.