

# 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 readout basis affect a quantum measurement.  
The research article can be accessed by clicking on [this link](#).
- **Phases of  $SU(2)$  gauge theory with multiple adjoint Higgs fields in 2+1 dimensions** *arxiv:1912.06108*, Dec 2019.  
Preprint of my research work on Gauge Theory of Cuprates under supervision of Professor Subir Sachdev.

## 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  $\phi^4$  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 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 measurement 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 **Gisin Theorem**
- Also studied **Stochastic calculus** and integration of SDE in **ito form** and **stratonovich form**.

## Silicon detector Calibrator

[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 impedance matching
- Understood and tested **Signal Transmission and Reflection** in Coaxial Cables.

## Course Projects

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### 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.
- Established 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

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### 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

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- 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

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### 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

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- 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.