Abhay Saxena

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Research Interests

Ultrafast & Terahertz Spectroscopy, Spintronics, Topological Materials, *Ab-initio* Methods, and Quantum Computation.

Education

Indian Institute of Science Education and Research (IISER) Kolkata — Mohanpur, India
5 Year BS-MS Dual Degree in Physical Sciences (Minor in Computational Data Sciences) — *Aug 2021 — Present*

- **CGPA:** 7.94 / 10 (till semester 9).
- Last two semesters: 9.1/10
- **Relevant Courses:** Condensed Matter Physics II, Advanced Quantum Mechanics, Quantum Information Processing, Soft Condensed Matter Physics, Quantum Field Theory, Computational Physics, Probability I, Linear Algebra I, Electrical Circuits & Electronics, Artificial Intelligence, Programming & Data Structures [Certificate].
- **Term papers:**

  2025: Landauer-Büttiker vs. Kubo Formalisms in Quantum Wire (Bosonization) [Term Paper, Presentation].
  Mentor: Prof. Amit Ghosal

  2024: Casimir Effect for Massless Fermions in One Dimension via a Force Operator Approach [Term Paper].
  Mentor: Prof. Sourin Das

- **Teaching Experience:** Teaching Assistant for Condensed Matter Laboratory (Fourth Year)

Navyug Convent School — Delhi, India
Senior Secondary (Class XII) — PCM — CBSE — *2021*

- **Percentage:** 92%

Cambridge School — Noida, India
Matriculation (Class X) — CBSE — *2019*

- **Percentage:** 96.4%

Research Experience

MS Thesis Student — Ultrafast Terahertz Spectroscopy (UFTS) Group — Aug 2025 — Present
Mentor: Prof. Kamaraju Natarajan — *IISER Kolkata, India*

- [Report]
- **Project:** Ultrafast Dynamics in Nickel Thin Films.
- Designed and aligned an optical pump-probe spectroscopy setup to investigate demagnetization dynamics in Cr(2nm)/Ni(10nm)/Cr(2nm) thin films, incorporating **helicity-dependent and MCD measurements**.
- Conducted fluence-dependent reflectivity measurements, observing potential acoustic phonon oscillations indicative of rapid lattice heating along with back substrate reflections.
- Analyzed thermal dynamics using fitting models and the **2TM (Groeneveld method)** and M3TM predictions to interpret electron-phonon coupling and spin dynamics.
- **Instrumentation:** Developed general-purpose automation for cryostat temperature control using **Python/NI-VISA** drivers for PID loops. Added sensor instrumentation for YBCO studies and optimized PID tables for long-duration stability. Verified Acousto-optic modulator alignment for 85% first-order output.
- Investigated long-period oscillations in Fe_2O_3 reflective pump-probe data.

Research Intern — Quantum NanoDevice Lab — May 2025 — July 2025
Mentor: Prof. Kuntal Roy — *IISER Bhopal, India*

- [Report]
- **Project:** Design and Assembly of FMR Setup & ST-FMR Theory.
- Independently designed and assembled a broadband Ferromagnetic Resonance (FMR) setup (**2–9 GHz**), integrating a lock-in amplifier, Helmholtz coils, picoammeter, Schottky diode, and Coplanar Waveguide (CPW).
- Developed a comprehensive **LabVIEW** automation suite to control current sources, lock-in amplifiers, and signal generators, enabling fully automated frequency and field sweeps.

- Gained theoretical understanding of Spin-Torque FMR (ST-FMR) phenomena, including inverse spin Hall effect (ISHE) mechanisms and spin pumping.

Research Project II — UFTS Group Dec 2024 — April 2025
Mentor: Prof. Kamaraju Natarajan *IISER Kolkata, India*

- [Presentation]
- Recreated David J. Hilton's characteristic matrix method to simulate Cyclotron Resonance in high-mobility 2DEGs with Circular Dichroism using MATLAB.
- Implemented the **Transfer Matrix Method (TMM)** in a novel fashion, to resolve satellite pulse interference caused by substrate reflections in Terahertz Time-Domain Spectroscopy (THz-TDS), significantly improving spectral resolution.

Summer Research Intern — Topological Insulators (Theory) May 2024 — July 2024
Mentor: Prof. Kuntal Roy *IISER Bhopal, India*

- Demonstrated deep understanding of topological materials, emphasizing Hall effects, SSH, Kane-Mele model, and Majorana Fermions.
- Utilized **Kwant** to analyze band structures of graphene nanoribbons for topological properties.

Quantum Computing Project May 2023 — July 2023
Mentor: Prof. Kuntal Roy (Remote) *IISER Bhopal, India*

- [Presentation] · [Report] · [GitHub]
- Title: Efficiency Comparison and Implementation of VQE, VQD, and p-VQD Algorithms in Qiskit.
- Studied various Eigensolvers and Time Evolver (p-VQD) algorithms; customized implementations of VQE and VQD on IBM Quantum backends (*ibmq_quito*) to analyze efficiency.

Coding Project in Django, Next.js, and JavaScript May 2023 — July 2023
Mentor: Prof. Dwaipayan Roy (CDS Dept) *IISER Kolkata, India*

- [Report] · [Certificate]
- Title: Exploring and Implementing a Robust Crediting Module in Canteen Management System.
- Integrated Cashfree and MobiKwik payment gateway systems into the student mess credit system using Python and JavaScript.

Achievements

TOEFL iBT (Oct, 2025): scored **107**/120 with scores above 26 in all sections.

Physics GRE (Oct, 2025): scored **820**/990.

JEE Advanced (2021): Qualified in the **top 2%** of candidates nationwide (AIR 18389) in Entrance Exam for IITs.

IISER Aptitude Test (2021): All India Rank (Overall) **1032** in Entrance Exam for IISERs.

Competitions: Zonal topper for SOF National Cyber Olympiad (Class 9); Secured top positions in multiple inter-school web design and mathematics competitions.

Technical Skills

Programming Languages: Python, C, MATLAB, JavaScript, Kotlin
Tools & Frameworks: LabVIEW, MEEP, VESTA, Qiskit, Kwant, SymPy, Arduino, SKlearn, LaTeX, Git
Operating Systems: Linux (Fedora, Debian; Bash scripting, system administration)
General Development Tools: Blender, Flutter, Android Studio, Django, React/Next.js

Student Interests & Coding Projects

Personal Website (2023): Completely coded and designed static personal website from scratch.[Link] .

Android Development (2022): Developed a Kotlin-based YouTube client on Android allowing website functionality modification and background action using GeckoView. [GitHub]

Cordova App (2016): Exercise app with spaced repetition timers and statistics, based on Cordova [GitHub]

IoT & Hardware: Experience with Arduino projects (Nokia 5110 display, HC-05, ESP8266 based IoT experiments); Attended IIT Delhi Rendezvous IoT Workshop for ESP WiFi Module.

Machine Learning: Completed Machine Learning Foundational Crash Course by Google AI; implemented fundamental Quantum Support Vector Machines using kernel tricks in Qiskit.

Volunteering (2023): Volunteered for regular classroom teaching for underprivileged children during summer vacation at *Ek Pehel*. [Link]

Workshops (2025): Workshop on Future of Sensing (OPTICA Student Chapter IISER Kolkata, TCS Research).