

# Tayyab Ali

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## ABOUT ME

From nanostructure modelling to classification of astronomical objects, computational techniques always stand in front to explain past, observe present, and predict the future. Being a computational physicist, I am well-crafted in scientific computing for numerical analysis, visual demonstrations, theoretical simulations, and extracting high-precision data of various real-world physical and chaotic aspects, with a prime interest of integrating AI in science to meet societal challenges.

## EDUCATION AND TRAINING

### Bachelor of Science in Computational Physics

**University of the Punjab** [ 10/09/2020 – 05/09/2024 ]

**City:** Lahore | **Country:** Pakistan | **Final grade:** 3.46/4.0

**Relevant Coursework :** Quantum Mechanics, Thermal and Statistical Physics, Solid State Physics, Numerical Analysis, Computational Physics Simulations, Scientific Computation, Applied Nuclear and Particle Physics

## WORK EXPERIENCE

### AI Engineer Intern

**Wellness Innovation (pvt) Limited** [ 02/09/2024 – Current ]

**City:** Karachi | **Country:** Pakistan

- Worked on agentic design patterns to build an industry-based autonomous codet-agent for production-quality code generation, debugging, and feature implementation using multi-agent framework autogen, utilizing llama- 70b-3.1-versatile with enhanced decision making through 3 well-crafted prompts in YAML format, which will solve real-world engineering tasks, especially GitHub issues.
- Created and run end-to-end test-cases for performance analysis and code coverage of codet-agent.
- Generated Embeddings by splitting context length for open-source LLMs using OllamaEmbeddings and OpenAIEmbeddings.
- Fetched docstring, function signatures, and source code by inspecting live objects in Python, using inspect module, and augmented it with LLM through RAG (Retrieval Augmented Generation).

### Teacher Assistant

**AZ Educator's Academy** [ 11/10/2021 – 10/07/2024 ]

**City:** Lahore | **Country:** Pakistan

- Taught O/A Levels Mathematics and Physics, alongside working on curriculum design aligned with academic requirements, lesson planning, and structure of reasoning to produce not just students but laboratory-of-minds.
- Used my computational skills for visual demonstration of desired lesson, like movement of Earth and Moon, to create positive, interactive, and engaged environment.

## VOLUNTEERING

[ 08/2023 – 12/2023 ] Event Coordinator

### CHEP Scientific and Literary Society, University of the Punjab

- Managed schedule disruptions, overlapping sessions, and indoor setups in collaboration with administrative team and the General Secretary.
- Organized 2 awareness debates on *Effect of Modern Technologies in Earth's Environment* and *Safe use of Modern Tools*, 1 singing audition, and 1 off-campus tour.

## COMPUTATIONAL PROJECTS

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### Simulating Ground State Energy of Lithium Hydride using Variational Quantum Eigensolver | Python

- Used Variational Quantum Eigensolver (VQE) from Qiskit to compute ground state energy of Lithium Hydride (LiH) by varying interatomic distances along z-axis, using variational methods in quantum mechanics, and compared it with exact value from classical computation.
- Encoded molecule's information into quantum computer using qubit and performed 1000 iterations before convergence with a variational distance of 0.5Å - 4.25Å having an interval of 0.25Å.
- Used HartreeFock as an ansatz and updated it through classical optimizer SLSQP.
- Enhanced computational speed using two-qubit-reduction and plotted the ground state energy as a function of interatomic distance.

### Variational Monte-Carlo Simulation for 1-Dimensional Quantum Harmonic Oscillator | Python

- Generated 10,000 samples using Metropolis-Hastings algorithm and computed local energy for each sample at learning and acceptance rate of 0.01 and 56.4%, respectively.
- Started by variational parameter of 0.5, and update it using gradient decent algorithm, which drops to 0.3293 by decay rate of 65.86%.
- By effective optimization, ground state energy is computed  $E = 0.5324$  with relative error of 6.48%.

### Bacterial Enhancement Model | C#

- Simulated bacterial spread and colony formation in human body by implementing DLA (Diffusion Limited Aggregation) and Eden cluster growth models using Monte-Carlo algorithm.
- Generated fractal visuals on 100-dimensional lattice, having each particle of circular shape with radius 10.
- Performed the box counting with unit length of box 2, to compute fractal dimension for DLA as  $D = 1.53$ , and compared it with dimensional fractal count of vessel formation/angiogenesis.

### Ising Model : Atomic Fluctuations and Spin Dynamics | C#

- Simulated spin dynamics due to thermal fluctuations, and process of magnetization under the effect of nearest neighbours causing spin value transitions from +1 (up) to -1 (down), and vice versa.
- Studied finite-size effects of spin atoms which caused 46.2% deviation of ground state energy.
- Generated graphical representation of variation in Entropy with time, due to temperature changes.

## CONFERENCES AND SEMINARS

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[ 04/2024 ] Condensed Matter and Statistical Physics, International Centre for Theoretical Physics

**Joint ICTP-WE Heraeus School and Conference on Frontiers at the Intersection of Quantum Simulation and Machine Learning**

[ 07/2023 ] Centre for High Energy Physics

**High Energy Scattering Visuals and Vacuum Fluctuations**

[ 01/2022 ] Centre for High Energy Physics

**Quantum Entanglement Measurement and Causality**

[ 07/2024 ] University of Hertfordshire, Uk

**Computational Techniques to Model Decelerating Relativistic Jets from Low Luminosity Radio Galaxies**

## DIGITAL SKILLS

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Python / C/C++ / C# / Mathematica / MATLAB / LaTeX / Scientific Workplace / DATABASE : SQL, SQL Lite / Windows Subsystem for Linux (WSL)

## HONOURS AND AWARDS

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Government of Pakistan

**Prime Minister's Laptop Scheme**

- Awarded a laptop in academic excellence from Prime Minister's Merit Based Laptop Scheme, 2023.