

# Ganga Singh Manchanda

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## EDUCATION

### Imperial College London

MSc Quantum Fields & Fundamental Forces, 80.52%

Graduated with Distinction

Nominated for Imperial President's Scholarship

Shortlisted for Bayforest Technologies Limited Prize

Oct 2023 - Oct 2024

### Imperial College London

BSc Physics with Theoretical Physics, First Class Honours

Oct 2020 - Jun 2023

## PUBLICATIONS

- [1] G. S. Manchanda, "When energy isn't enough: Understanding structural failures in VQE", *Preparing for submission to Phys. Rev. A*.
- [2] G. S. Manchanda, "A classification of gauge degrees of freedom in constrained Hamiltonians", *in progress*.
- [3] J. Magueijo and G. S. Manchanda, "Quantum wormholes at spatial infinity", *Phys. Lett. B* **864**, (2025) 139434.

## RESEARCH EXPERIENCE

### Imperial College London

Postgraduate Researcher - Quantum Optics and Laser Science Group

London, England

Jun 2025 - Present

- Independently initiated research in Quantum Computing after identifying a poorly understood failure mode of the Variational Quantum Eigensolver.
- Joined QOLS to receive help formalising my results and understanding their wider implications.
- Currently preparing a manuscript for submission to *Physics Review A*.

### Imperial College London

Postgraduate Researcher - Abdus Salam Centre for Theoretical Physics

London, England

Oct 2024 - Mar 2025

- Co-authored a peer-reviewed paper in *Physics Letters B* in the field of Canonical Quantum Gravity.
- Collaborated at every stage of the research process, from model building and theoretical analysis to interpretation of results, addressing key challenges along the way.
- Independently began a follow-up paper addressing key questions raised about gauge degrees of freedom.

## SELECTED PROJECTS

### When energy isn't enough: Understanding structural failures in VQE

- Identified how VQE can fail to reproduce correct entanglement spectra in the 1D/2D TFIM even when energy is successfully minimised
- Developed a toy-model to expand upon this and demonstrate that failure may occur in Hamiltonians with near degenerate low-energy states.
- Theoretically bounded the maximum error from this phenomenon using perturbation theory and proposed how one can avoid falling into similar traps

### Quantum wormholes at spatial infinity

- Co-developed a theory of quantum wormholes which exist at spatial infinity and whose existence is enforced by unitarity in quantum gravity.

- Worked with constrained Hamiltonians to derive and solve Wheeler-DeWitt partial differential equations using a variety of theoretical techniques, numerical methods, and approximation schemes.
- Predicted corrections to the far out Newtonian potential due to attraction from across the wormhole.

### Distances in Discrete Space-time

- Investigated various measures of distance in causal set space-times by analysing procedurally generated directed acyclic graphs.
- Developed algorithms to identify extremal chains under the class of metrics defined by the Minkowski distance.
- Identified phase transitions in geodesic behaviour and discussed the Lorentzian continuous structure expected to emerge under coarse-graining.

### Investigations on the Barabási-Albert model

- Simulated large networks ( $10^6$  nodes), modelling stochastic and preferential growth to study critical exponents in network structure evolution.
- Employed statistical methods including log-binning,  $\chi^2$  testing, Kolmogorov-Smirnov testing, and data collapse to validate scale-free behaviour and finite-size effects.
- Built efficient analysis tools in Python to visualise behaviour across hundreds of simulations and graph sizes.

## RELATED EXPERIENCE

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### Meditations on Second Philosophy (Physics & Philosophy Blog)

Creator \ Writer

Online

Jun 2025 - Present

- Explored and communicated foundational issues in Quantum Mechanics and Gravity.
- Producing an article to contribute to the 3Blue1Brown Summer of Math Exposition.

### Visely (AI EdTech Company)

Academic Writer

(Remote) London, England

Mar 2025 - Present

- Generated graduate-level exam questions in topics ranging from Riemannian Geometry to Quantum Information.
- Designed and refined LLM prompts to improve solution accuracy and academic rigour, ensuring high-quality content.

### Tutorful

Private Tutor

Online

Mar 2025 - Present

- Tutored students taking A-level and undergraduate examinations in Physics and Mathematics.
- Led students to improve their grades from the ranges B/C to A/A\*.

### Imperial College Punjabi Society

President \ Vice-President

London, England

Oct 2022 - Jun 2024

- Oversaw operations and co-organized the UK's largest annual student-run dance competition (~£50,000 budget).
- Represented Imperial on stage in our national competition (The Bhangra Showdown).

## TECHNICAL SKILLS

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Programming: Python (PennyLane, NumPy, SciPy, Pandas, Matplotlib, NetworkX), Git, Jupyter, L<sup>A</sup>T<sub>E</sub>X

Languages: English, Punjabi, Hindi, French, Thai

REFERENCES AVAILABLE UPON REQUEST