

# Snehal Raj

PHD STUDENT · SORBONNE UNIVERSITÉ · UNIVERSITY OF OXFORD · IIT KANPUR

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## Research Summary

My research develops quantum and quantum-inspired machine learning algorithms, from theory to deployment. I design trainable quantum circuit architectures and validate them on near-term hardware, with applications in quantitative finance, machine learning, and scientific simulation. I also build classical methods inspired by quantum machine learning approaches, bridging quantum computing and practical ML.

## Education

### Sorbonne University

Paris, France

PHD IN QUANTUM MACHINE LEARNING

2024 - Present

ADVISOR: PROF. ELHAM KASHEFI

- Established learnability, trainability, and sampling hardness results for fermionic linear optics circuits, proving trainability for Z-string observables and efficient learning from matchgate shadow measurements.
- Designed QuIC Adapters, a quantum-inspired PEFT method achieving **over 40x parameter compression** vs LoRA for fine-tuning LLaMA and vision transformers, with **less than 0.02% memory footprint**.
- Developed a permutation-equivariant quantum GNN matching **state-of-the-art classical GCN performance** on graph optimization.
- Introduced density quantum neural networks (**NPJ QI 2025**) and ForCANS, a measurement-aware optimizer that reduces the number of quantum circuit evaluations required for variational training.

### University of Oxford

Oxford, United Kingdom

MSC IN ADVANCED COMPUTER SCIENCE

2021 - 2022

ADVISOR: PROF. ALEKS KISSINGER

- Distinction** in coursework and thesis.
- Developed methods for quantum circuit simulation combining ZX-calculus graph rewriting with tensor network contraction [thesis].
- Contributed to **PyZX**, an open-source library for quantum circuit optimization.

### Indian Institute of Technology, Kanpur (IIT-K)

India

B.TECH IN COMPUTER SCIENCE AND ENGINEERING

2017 - 2021

ADVISOR: PROF. RAJAT MITTAL

- GPA: 9.52/10. Undergraduate thesis on polynomial methods in quantum query complexity. Exchange semester at Université Paris Diderot.

## Experience

### QC Ware Corp

Paris, France (prev. Remote)

ASSOCIATE STAFF SCIENTIST (PREV. RESEARCH CONTRACTOR)

Aug. 2020 - Present

MANAGER: DR. IORDANIS KERENIDIS

- Core developer** of QC Ware's Quantum Neural Network library, a hardware-agnostic platform built from scratch in JAX with production-grade integrations for PyTorch, TensorFlow, and Scikit-learn. Distributed on **AWS Marketplace**.
- Led or co-led 8 client engagements** across quantitative finance, supply chain optimization, and industrial applications with **JPMC, Citi, UBS, Wells Fargo, Itau Unibanco, Aisin Corp, BMW, and Airbus**.
- Co-developed Quantum Deep Hedging with JPMC, published in **Quantum** journal and featured in a **Forbes** article.
- Led a **multi-year supply chain optimization** engagement with Aisin Corp, one of the company's largest client projects.
- Conducted research on trainable quantum circuits for quantitative finance, contributing to **3 peer-reviewed publications**.

### Adobe Research

Bangalore, India (Remote)

RESEARCH INTERN

Apr. 2020 - Aug. 2020

MANAGER: DR. NIYATI CHHAYA

- Built an AutoML pipeline for Adobe's Document Cloud, distilling large language models (BERT/GPT-2) into compact summarization models.
- Work resulted in a publication at **EMNLP 2021** and an **invention disclosure/patent** filed under Adobe's IP policies.
- The pipeline was integrated into Adobe's Document Cloud for **automated text summarization** across multiple document types.

# Publications

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## The Hamming Weight Landscape of Fermionic Linear Optics

Snehal Raj, Elham Kashefi

*In Preparation*

2026

## QulC: Quantum-Inspired Compound Adapters for Parameter Efficient Fine-Tuning

Snehal Raj, Brian Coyle

*In Submission*

2026

## Quantum Graph Neural Networks with Permutation-Equivariant Message Passing

Snehal Raj, Brian Coyle, Léo Monbroussou, André J. Ferreira-Martins, Renato M. S. Farias, Elham Kashefi

*In Submission*

2026

## Training Quantum Circuits with Directional Derivatives

Brian Coyle, Snehal Raj, El Amine Cherrat

*In Submission*

2026

## Bayesian Quantum Orthogonal Neural Networks for Anomaly Detection

Natansh Mathur, Brian Coyle, Nishant Jain, Snehal Raj, Akshat Tandon, Jasper Simon Krauser, Rainer Stoessel

*IEEE Quantum Week*

2025

## Training-efficient density quantum machine learning

Brian Coyle, Snehal Raj, Natansh Mathur, El Amine Cherrat, Nishant Jain, Skander Kazdaghli, Iordanis Kerenidis

*NPJ Quantum Information*

2025

## Quantum Deep Hedging

El Amine Cherrat\*, Snehal Raj\*, Iordanis Kerenidis\*, Abhishek Shekhar, Ben Wood, Jon Dee, Shouvanik Chakrabarti, Richard Chen, Dylan Herman, Shaohan Hu, Pierre Minssen, Ruslan Shaydulyn, Yue Sun, Romina Yalovetzky, Marco Pistoia. **[Forbes]**

*Quantum*

2023

## AUTOSUMM: Automatic Model Creation for Text Summarization

Sharmila Reddy Nangi, Atharv Tyagi\*, Jay Mundra\*, Sagnik Mukherjee\*, Snehal Raj\*, Niyati Chhaya, and Aparna Garimella

*EMNLP*

2021

\* denotes equal first authorship or equal contribution.

# Honors & Awards

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2024 **CIFRE PhD Scholar**, ANRT Association Nationale de la Recherche et de la Technologie

2022 **Distinction**, For coursework and thesis, University of Oxford

2020 **Academic Excellence Award**, For all years 2017, 2018, 2019, 2020 at IIT Kanpur

2019 **Inter-IIT Gold Medal**, Inter-IIT Tech Meet

2017 **All India Rank 168**, Joint Entrance Exam Advanced, 200,000 candidates

2016 **Indian Olympiad Teams**, Selected for Indian teams in Mathematics (RMO) and Physics (NSEP)

# Talks & Teaching

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2026 **Invited Speaker**, Nordita Workshop on Quantum Machine Learning, tutorial-style lecture series

*Stockholm*

2025 **Long Oral**, QTML 2025: Bayesian Quantum Orthogonal Neural Networks for Anomaly Detection

*Singapore*

2025 **Instructor**, ACM India Summer School on Quantum Circuits and Quantum Algorithms

*India*

2024 **Long Oral**, QTML 2024: Training-efficient density quantum machine learning

*Melbourne*

2026 **Mentor**, Supervised master students on quantum machine learning research projects

*Sorbonne University*

2021 **Teaching Assistant**, Data Structures and Algorithms, under Prof. Anil Seth

*IIT Kanpur*

2020 **Project Mentor**, ProML, Association of Computing Activities

*IIT Kanpur*

# Professional Activities

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**Reviewer:** IEEE Transactions on Quantum Engineering ('24, '25) · IEEE QCE ('25) · QC-TIP ('24, '25) · QTML ('24, '25)