# Vanshaj Bindal

## Example Gallery Project - Toqito - GSoC 2025

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## MOTIVATION LETTER

Dear Toqito Mentors,

I am excited to apply for the opportunity to contribute to Toqito as part of Google Summer of Code (GSoC) 2025. My academic background, research experience, and passion for quantum open-source projects have driven me to pursue this opportunity. I believe my skills and experience align well with Toqito's goals and will enable me to make a meaningful contribution to the project.

I recently completed my MSc in Physics at Cardiff University, specialising in quantum information and theoretical physics. Throughout my studies, I gained hands-on experience with a range of quantum information tools and techniques, particularly in quantum simulations, quantum error correction, and tensor network models.

One of my notable projects at Cardiff University involved simulating the Jaynes-Cummings model in cavity QED using QuTiP. This project required modeling the interaction between a two-level atom and a single mode of the electromagnetic field. I developed a simulation framework that analysed both coherent and dissipative processes in the system. This experience strengthened my foundation in quantum simulation, numerical methods, and writing open-source code for research applications, skills that are highly relevant for the GSoC project I wish to undertake.

For my master's thesis, I explored holographic quantum error correction, a topic at the intersection of quantum information theory, quantum error correction, tensor networks, and AdS/CFT. My research focused on how holographic codes serve as toy models for AdS/CFT and how they facilitate encoding information between bulk (logical) and boundary (physical) degrees of freedom. This work honed my analytical skills and deepened my understanding of quantum error correction and quantum state protection, concepts crucial to the quantum open-source community.

Beyond academics, I got selected for the Quantum Open Source Foundation (QOSF) mentorship program. During the screening phase, I developed a quantum state-vector simulator using matrix and tensor-based approaches to simulate quantum circuits, perform runtime analysis, and conduct scalability testing. Currently, I am working on a project involving time evolution algorithms in the Pauli basis, specifically the Pauli propagation technique using Julia. Through this project, I am comparing different numerical methods within a simulation framework to identify the most efficient approach. This hands-on experience has reinforced my interest in contributing to the quantum open-source ecosystem.

I am deeply passionate about quantum open-source projects because they bridge the gap between research and real-world applications. Toqito's mission aligns with my commitment to making quantum tools accessible and well-documented, enabling a broader audience to engage with quantum information theory. Contributing to Toqito will not only enhance my quantum programming skills but also allow me to work on real-world applications of quantum information theory. The Example Gallery Project excites me in particular, as it provides an opportunity to improve Toqito's documentation and usability, making the library more approachable for users.

With my background in quantum information, numerical methods, and Python programming, I aim to design structured, high-quality example scripts that effectively demonstrate Toqito's core functionalities in an accessible manner.

I look forward to discussing my proposal further and exploring how I can contribute to Toqito. Thank you for considering my application.

Best regards,

Vanshaj Bindal