

Ms. Karabee Batta

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RESEARCH STATEMENT

I am a dedicated and inquisitive researcher, eager to contribute to cutting-edge research. My primary research interests include quantum communication, particularly free-space QKD links, and exploring applications in space science. I am enthusiastic about working on the interdisciplinary potential of these fields and advancing knowledge at their intersection.

ACADEMIC DETAILS

Examination/Degree	Discipline	Institute	Year	CGPA
PhD	Physics	University of Bristol	Incoming	
Master of Science (MSc.)	Quantum Science and Technology	Technische Universität München (TUM) & Ludwig-Maximilians-Universität München (LMU)	Oct 2023 – Sep 2025	1,7
Visiting Student Researcher	Physics and Astronomy	University of Calgary	Jan 2020 – May 2022	3.65/4
Bachelor of Engineering; Minor	Computer Engineering; Physics	BITS Pilani	Aug 2016 – May 2020	7.2/10
Grade 12	–	Bal Niketan Secondary School	2016	9.58/10
Grade 10	–	Sacred Heart Convent School	2014	10/10

WORK AND RESEARCH EXPERIENCE

- Thesis Student and Graduate Research Assistant with Prof. Dr Harald Weinfurter's group at LMU (November 15, 2023 - May 27, 2025)
- Research Assistant with Assoc. Prof. Dr. Alexander Ling's group at the Centre for Quantum Technologies (May 10, 2023 - September 30, 2023)
- Online Tutor for Mathematics, Science and English (September 21, 2021 - present)
- Student Research Assistant with Assoc. Prof. Dr Daniel Oblak's group at the University of Calgary, Calgary (Jan 26, 2020 - May 31, 2022)
- Teaching Assistant for IBM's Qiskit course (May 1, 2021 - Jun 30, 2021)
- Visiting Student under Prof. Dr Ujjwal Sen at HRI, Allahabad (May 26, 2019 - Jul 26, 2019)
- Team Lead of the Attitude Control and Determination System the student helmed satellite Anant at BITS Pilani (Sept 1, 2016 - May 31, 2019)
- Junior Research Assistant under Assoc. Prof. Dr Kaushar Vaidya at BITS Pilani (Jan 5, 2019 - May 31, 2019)
- Junior Research Assistant under Prof. Dr Navneet Goyal at BITS Pilani (Aug 1, 2018 - Dec 3, 2018)
- Visiting Student under Prof. Dr Joydeep Bagchi at IUCAA, Pune (Jun 1, 2018 - Jul 31, 2018)

WORKSHOPS AND CONFERENCES

- **The 3rd International Network in Space Quantum Technologies (INSQT)** (August 30 - September 2, 2023 at Berlin, Germany)
Presented a poster on our work at the University of Calgary on *Low-Earth Orbit Satellite-based Quantum Communication using a BB84 Decoy-state Protocol*.
- **Quanta Alberta Symposium** (September 10 - 11, 2022 at Calgary, Canada)
The workshop focussed on discussing developments and potential applications of architectures for the space quantum internet (SQI) era and the applications of quantum memories in the same.
- **QKD summer school at the University of Waterloo** (August 15 - 24, 2022 at Waterloo, Canada)
The workshop focused on teaching about theoretical and experimental aspects of Quantum communication with emphasis on quantum cryptography. It will be followed by a three-day workshop on using and developing open-source numerical QKD software tools.
- **Photonics North 2022** (May 24 - 26, 2022 at Niagara, Canada)
Presented our team's current progress in *Establishing successful QKD links with the low-earth orbit satellite Micius via a receiver ground-station at the University of Calgary*.
- **Quantum Days 2022** (Feb 8 - 10, 2022 (online conference))
Presented a poster on our work on *Establishing free space QKD links with Micius with special emphasis on characterising background light profile*. Was awarded the first prize in the best poster category.
- **The 6th Annual Undergraduate Research in Science Conference of Alberta (URSCA)** (May 25 - 26, 2020 at Lethbridge, Canada)
Presented my work on *bench-marking the ground station for quantum satellite communication in Calgary*. Was awarded the second prize in my category.
- **The 69th International Astronautical Conference** (October 1 - 5, 2018 at Bremen, Germany)
Presented the paper: "*Comparative Study between classical and fuzzy PID Controllers using extended Kalman filters for cubesats*".
- **The 68th International Astronautical Conference** (Sept 24-29, 2017 at Adelaide, Australia)
Presented the paper: "*Design and Development of a three-axis controlled Helmholtz Cage as in-house magnetic field simulator for cubesats*".

PUBLICATIONS (inc.pre-prints)

- An optical ground station in Singapore for satellite-to-ground quantum communication: 2023 IEEE International Conference on Space Optical Systems and Applications (ICSOS).
- An Analysis of Anthropogenic Light for Optical Quantum Communication and Optical Quantum Ground Station Deployment: 9th International Conference on Artificial Light At Night(ALAN).
- Comparative Study between classical and fuzzy PID Controllers using extended Kalman filters for CubeSats: Journal of the International Astronautical Congress (2019).
- Design and Development of a three-axis controlled Helmholtz Cage as in-house magnetic field simulator for CubeSats: Journal of the International Astronautical Congress (2018).

TECHNICAL SKILLS

- **Programming Languages:** C, C++, Python, Java and Scala.
- **Scripting Languages:** Python, Shell and R.
- **Tools and Applications:** Autodesk Fusion, Eclipse, $\LaTeX$, Gnu-plot, Matlab, Qiskit, Pyquil, Orbitron and PyBDS.

RELATED COURSES

- **At TUM and LMU**
Quantum Information, Quantum Hardware, Quantum Communication, Photonic Quantum Technologies, Spin Qubits, Quantum Opto-Electronics, Application of Quantum Computing

- **At the University of Calgary**
Advanced Quantum Mechanics, Quantum Optics
- **At BITS Pilani**
Quantum Information and Computing, Design and Analysis of Algorithms, Statistical Mechanics, Quantum Mechanics, Computer Networks, Computer Architecture and Machine Learning.

TEST SCORES

Examination	Percentile/Score	Year
GRE-Physics	722/1000	2021
TOEFL	116/120 (Absolute Score)	2023
GRE	332/346(Absolute Score)	2019
JEE	98.5 (Percentile Score) (Examination taken by over 1.2 million students)	2016
BITSAT	99.0 (Percentile Score) (Examination taken by over 400 thousand students)	2016

MAJOR PROJECTS

- **Thesis Project: Designing an active polarization compensation scheme for free space QKD links**
Ludwig Maximilians Universität, München (Supervisor: Prof. Dr. Harald Weinfurter; October 1, 2023 - May 27, 2025) The SKALE project is a collaborative endeavour by various research groups and industry partners to create a free-space quantum communication network in Munich. The compact receiver module will be compatible with multiple sender units, including QUBE-II, the 3U nano-satellite designed by our group in collaboration with DLR (the German Aerospace Centre).
 - I developed a dynamic polarisation compensation scheme using motorized waveplates to compensate for unitary transformations a qubit may experience due to interactions with optical elements along its path from the source to the receiver.
 - This involved developing code to control the waveplate orientation and integrating it to actively compensate for arbitrary transformations during the satellite pass.
- **Developing the receiver terminal for the QUBE-II Satellite**
Ludwig Maximilians Universität, München (Supervisor: Prof. Dr. Harald Weinfurter; November 15, 2023 - August 31, 2024)
Our team is currently building QUBE-II, a 3U low-earth-orbit satellite, to distribute a quantum key between a satellite and a ground station. I worked on developing the receiver terminal. The receiver's primary task is to direct incoming photons from the satellite into one of the four channels, corresponding to the four measurement bases, to carry out the BB84 decoy-state protocol. The receiver must also be compact enough to fit into the 3U satellite. We periodically conduct free space link tests at the DLR (German Aerospace) centre in Weißling, on the outskirts of Munich. My work also included programming the receiver module and simulating the free space link to identify problems in the link budget and optimise accordingly.
- **Developing and characterising payload for the SpeQtral-1 satellite**
Centre of Quantum Technologies, National University of Singapore (Supervisor: Assoc. Prof. Dr. Alexander Ling; May 10, 2023 - September 30, 2023)
Dr. Ling's group launched the SpooQy-1 cubesatellite in April 2019. Its main goal was to demonstrate in orbit a space-compatible quantum light source to increase the Technology Readiness Level (TRL) of future global Quantum key distribution (QKD) networks. Having done that successfully, the group is currently preparing its successor SpeQtral-1, with the space startup SpeQtral. It will demonstrate the technological feasibility of intercontinental out-of-band symmetric key delivery with a focus on addressing the practical commercial requirements of end nodes.
 - I worked on characterising the opto-mechanical equipment of the payload and helped create the link budget for it.
 - I worked on demonstrating that our current ground-station mount could successfully capture satellites in the field of view of a Forward Looking InfraRed (FLIR) camera and track them continuously.
- **Setting up a ground station for free-space quantum communication using low earth orbit satellites**
University of Calgary, Calgary (Supervisor: Assoc. Prof. Dr. Daniel Oblak; Feb 3, 2020 - May 31, 2022)

The Chinese satellite Micius was launched in 2016 to carry out quantum experiments in outer space. It also acted as a trusted node for quantum key distribution, enabling communication between ground stations in Xinglong, China, and Graz, Austria. The Quantum Cloud Lab, led by Dr. Daniel Oblak, is working to establish a third ground station in Calgary, one of the first of its kind in Canada.

- I had been involved in the project since its conception and initial setup at the University of Calgary. I performed characterisation and pre-usage setup of all the equipment and integrated the various components of the ground station.
- I worked on gauging the background light noise and the signal that it will encounter at its operational wavelength of 850nm, and finding optimal techniques to reduce noise.
- To check if the experimental and theoretical results coincided, I took spectrometric readings of the atmosphere around the ground station, specifically taking into consideration light pollution, lunar flux, and the time and weather conditions.
- Apart from background light characterisation, we performed post-processing of the received qubits at the ground station. We then carried out privacy amplification and error correction on our end using the raw key data. This involved time synchronisation of the transmitted and received qubits, basis sifting and error correction, followed by privacy amplification.
- **Scope:** In the future, this ground station will be used for communication with other satellites using quantum communication protocols. We are also the tertiary ground station for the Canadian satellite QEYSSat, where we will function as a transmitting node.

- **Tri-partite entanglement of black hole systems (Research Project)**

Harish Chandra Research Institute, Allahabad (Supervisor: Prof. Dr. Ujjwal Sen; May 26, 2019 - Jul 26, 2019)

I learned about **trans-event horizon entanglement of tri-partite black hole systems**, i.e., among the qubits, as part of my summer internship.

- **Student helmed nano-satellite project, Anant**

BITS Pilani, in collaboration with the Indian Space Research Organization (ISRO)

(Supervisor: Assoc. Prof. Dr. Kaushar Vaidya; Sept 1, 2016 - May 31, 2019)

Team **Anant** is the nano-satellite building team of BITS Pilani working under the guidance of ISRO. Our payload, which is a hyperspectral imaging camera, will monitor the carbon cycles over the Indian Ocean. This information can be used to predict weather patterns, which might be beneficial to India's agrarian economy.

I was the team lead of the Attitude Determination and Control (ADC) subsystem of the satellite. This subsystem is responsible for maintaining the satellite in an optimal position in space. My work includes:

- I worked on finding the optimal placement of solar sensors on the faces of the cube-sat to optimize solar power utilization.
- I mapped out the post-deployment trajectory of the satellite and encoded the trajectory for use by onboard computing system.
- After deployment, as the satellite tumbles in free space, the attitude control measures are initialised. Magnetorquers and reaction wheels are the 2 levels of control we have used in our satellites. I designed a reaction wheel controller to achieve momentum dumping.
- I also managed online meetings with distributors to acquire COTS components.

- **Identification of main sequence stars**

BITS Pilani (Supervisor: Assoc. Prof. Dr. Kaushar Vaidya ; January 10, 2019 - May 31, 2019)

- Using the data made available by the GAIA-DR2 sky survey, I studied 10 arc minute wide stellar environments. I identified main sequence star clusters, based on criteria such as the parallax values, declination and ascension, and radial velocities of stars. In addition, I plotted a color magnitude diagram for each cluster. I worked on isochrone fitting of the clusters to further remove noise and stray cosmic objects.

- **Automated detection of Radio Galactic families**

Inter University of Astronomy and Astrophysics, Pune (Supervisor: Prof. Dr. Joydeep Bagchi; Jun 1, 2018-Jul 31, 2018)

- **Objective:** To detect and separate radio galaxies from ambient sources
- I processed the data from the Very Large Array and Sloan Digital Sky surveys using PyBDS. In addition, I used the data to design an algorithm that would help identify radio-galactic families in a radio-loud environment.

- I separated the galaxies from singular clusters and noise based on their physical structures, kinematic properties, and their separation from Earth using my analysis algorithm.
- The algorithm will help make the process of identification of galaxies more efficient and quicker than the existing manual methods in use.
- **Scope:** This process can be further optimised and can also be implemented using convolutional neural networks.

MISCELLANEOUS PROJECTS

- **Setting up the web server for a background light detection unit**

Ludwig-Maximilian University, Munich (Supervisor: Prof. Dr. Harald Weinfurter; October 22, 2024 - present)

I am working on building a web server to automate the start of a portable background light detection unit, which consists of an open fibre unit and actuation motors running on a Raspberry Pi system.

- **Modelling an altitude simulator using genetic algorithms**

University of Calgary (Supervisor: Prof. Dr. Michael Wieser; Sept, 2021 - Dec, 2021)

I used genetic algorithms to create a self-learning evolving code that can be used on height elevation for drones. I then interfaced my Python code with Arduino and the hardware to develop a working prototype of the same.

CO-CURRICULARS AND CURRENT PROJECTS

- *Online tutor* for English, Science, and Maths, and extracurricular academic examinations: from grades 6 to 12.20 - October 2023)
- *Content Writer and Junior News Assistant* at **The Gauntlet**, the university of Calgary's independent student newspaper. September 2020 - May 2022).
- *Student Teaching Assistant* for the online course: **Introduction to Quantum Computing**, sponsored by IBM Quantum. (October 2020 - March 2021).
- *Co-founded* a **Quantum Information Research Group** under the guidance of 2 professors at BITS Pilani to promote interest in the field and collaborate on projects.
- Member of the **Royal Astronomical Society of Canada** (Calgary Chapter).
- Member of the **Space Generation Advisory Council**, a United Nations-supported global network of students and space professionals.
- Member of the student-founded Astronomy Club, BITS Pilani.
- Member of the Student Society of Mess Services, Election Commission: (August 2019 - May 2020).

FELLOWSHIPS AND AWARDS

- Winner of the best poster award at Quantum Days: February 2022
- Winner of the best talk at URSCA: May 2021
- Kishore Vigyan Protsahan Yojana (KVPY) Fellow: May 2016
- All India Talent Scholar Award: January 2013

LINGUAL PROFICIENCY

- Full professional proficiency: English, Hindi, and Punjabi
- Basic conversational proficiency: German

INTERESTS AND HOBBIES

- Sketching and painting serve as a calming and creative outlet for me. I especially enjoy working with watercolours and oil pastels.
- I am an avid reader who enjoys books from all genres, but I have a soft spot for the classic whodunnits.
- I took up running during the pandemic, and I have come to really enjoy it as part of my routine.

REFERENCES

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