Junseo Lee

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Research Interests

Quantum Learning Theory, Quantum Complexity Theory, Quantum Algorithms, Theoretical Computer Science

Education

Yonsei University *Seoul, Korea*
Bachelor of Science in Electrical and Electronic Engineering Mar. 2019 – Feb. 2023
Fully funded by the *Hyundai Motor Chung Mong-Koo Foundation* (2021–2022); *High Honors* (2022); *Honors* (2020-2021)

Chungnam Science High School *Gongju, Korea*
Concentration in Mathematics, *Early Graduation (Top 20%)* Mar. 2017 – Dec. 2018

Research Experience

Norma Inc. (Alternative Military Service) *Seoul, Korea*
Professional Research Personnel[(a)], Research Scientist (Quantum AI Team) Jan. 2023 – Present
- Provided technical consulting on quantum software and near-term algorithm design for government-funded projects.
- Conducted theoretical and numerical research on quantum algorithms for topological data analysis [11, 13] and on hybrid quantum-classical generative machine learning models [8].

Research Institute of Mathematics (RIM), Seoul National University (SNU) *Seoul, Korea*
Research Associate, Quantum Information Theory Group Jan. 2023 – Present
Research Assistant (Advisor: Dr. Kabgyun Jeong) Mar. 2020 – Dec. 2022
- Collaborated with international research groups at Inria Paris, UT Austin, FU Berlin, Scuola Normale Superiore, Stony Brook University, and the Center for Theoretical Physics of the Polish Academy of Sciences.
- Conducted theoretical research on quantum entropy functionals [3–5], quantum property estimation [6, 7, 9, 10], quantum polynomial hierarchies and proof systems [12], and quantum unitary tomography for bosonic systems [14].

Publications

$(\alpha\text{-}\beta)$ Authors listed alphabetically (theoretical computer science convention). *Equal contribution.

Preprints

[15] $(\alpha\text{-}\beta)$ D. Ji, **J. Lee**, A. Sawicki, O. Słowik. Explicit bounds on polylogarithmic spectral gap decay in unitary channels.

[14] $(\alpha\text{-}\beta)$ M. Fanizza, V. Iyer, **J. Lee**, A. A. Mele, F. A. Mele. Efficient learning of bosonic Gaussian unitaries. arXiv:2510.05531.
- Accepted for a regular talk at the 29th Annual Conference on **Quantum Information Processing (QIP 2026)**.

[13] N. A. Nghiem, **J. Lee**, T.-C. Wei. Hybrid quantum-classical framework for Betti number estimation with applications to topological data analysis. arXiv:2508.01516.

[12] $(\alpha\text{-}\beta)$ K. Anand, K. Jeong, **J. Lee**. Collapses in quantum-classical probabilistically checkable proofs and the quantum polynomial hierarchy. arXiv:2506.19792.

[11] $(\alpha\text{-}\beta)$ **J. Lee**, N. A. Nghiem. New aspects of quantum topological data analysis: Betti number estimation, and testing and tracking of homology and cohomology classes. arXiv:2506.01432.

Journal Articles

[10] D. Ji, **J. Lee**, M. Shin, I. Sohn, K. Jeong. Bounding quantum uncommon information with quantum neural estimators. *Quantum Science and Technology* **11**, 015001 (2026).

[9] M. Shin*, **J. Lee***, S. Lee, K. Jeong. Resource-efficient algorithm for estimating the trace of quantum state powers. *Quantum* **9**, 1832 (2025).

[8] M. Lee, M. Shin, **J. Lee**, K. Jeong. Mutual information maximizing quantum generative adversarial networks. *Scientific Reports* **15**, 32835 (2025).

[7] M. Shin*, S. Lee*, **J. Lee***, D. Ji, H. Yeo, K. Jeong. Disentanglement provides a unified estimation for quantum entropies and distance measures. *Physical Review A* **110**, 062418 (2024).

[6] M. Shin, **J. Lee**, K. Jeong. Estimating quantum mutual information through a quantum neural network. *Quantum Information Processing* **23**, 57 (2024).

[5] **J. Lee**, K. Jeong. Quantum Rényi entropy functionals for bosonic gaussian systems. *Physics Letters A* **490**, 129183 (2023).

[4] **J. Lee**, H. Yeo, K. Jeong. Weighted p-Rényi entropy power inequality: Information theory to quantum Shannon theory. *International Journal of Theoretical Physics* **62**, 253 (2023).

[3] **J. Lee**, K. Jeong. High-dimensional private quantum channels and regular polytopes. *Communications in Physics* **31**, 189 (2021). *Third Prize, Undergraduate Research Exhibition, Korean Physical Society* (2021).

[(a)] A selective national service program in South Korea enabling qualified scientists to complete military service through three years of full-time research in industry.

[2] K. Jeong, **J. Lee**, *et al.* Single qubit private quantum channels and 3-dimensional regular polyhedra. *New Physics: Sae Mulli* **68**, 232 (2018). *Bronze Award, The Humantech Paper Award, Samsung Electronics* (2018).

Book Chapters

[1] **J. Lee**. Assessing Quantum Integer Factorization Performance with Shor's Algorithm. In *Quantum Computing: A Journey into the Next Frontier of Information and Communication Security* (eds. M. Hammoudeh, A. T. Alessa, A. M. Sherbeeni, C. M. Firth, A. S. Alessa). *CRC Press* (2024).

Patents

K. Jeong, M. Shin, **J. Lee**. Method for estimating quantum mutual information through a quantum neural network. Korea Patent Application No. 10-2024-0104765 (pending, 2024).

Selected Honors and Awards

Funding and Fellowships

PhD Study Abroad Fellowship[(b)], *Hyundai Motor Chung Mong-Koo Foundation*	2026 (Expected)
Academic Travel Grant (for QIP 2022, Caltech), *Hyundai Motor Chung Mong-Koo Foundation*	2022
Full Scholarship in Intelligence Information Technology, *Hyundai Motor Chung Mong-Koo Foundation*	2021–2022
Teaching Fellowship (Software Courses), *Yonsei University*	2021–2022

Additional Honors and Awards

Best Tutor Award, *Innovation Center for Teaching and Learning, Yonsei University*	2021–2022
Selected Paper Award, *Finance and Economics Contest, DB Group*	2022
Outstanding Translator Award (with Travel Prize), *NAVER Connect Foundation and Khan Academy*	2018
Gold Award (Regional), Honorable Mention (National), *Korean Olympiad in Informatics (Middle School Division)*	2016

Professional Activities

Journal Reviewer: IEEE Transactions on Information Theory, Physical Review Letters, Physical Review Research, Physical Review Applied, Physical Review A, Annalen der Physik

Conference Reviewer: Quantum Techniques in Machine Learning (QTML 2025)

Community Service

Creator and Maintainer, Quantum Learning Theory Zoo *(curated database of quantum learning papers)*	2025–Present
Selection Committee, Quantum Internship Program, organized by *National Information Society Agency*	2024–2025
Co-organizer, Quantum Information Theory Seminar (QST Seminar), *Seoul National University*	2024–2025
Co-organizer, Quantum AI Hackathon, jointly organized by *Kakao Enterprise Corp., and Jeonju University*	2025
Facilitator (Mentor), Mathematics Section, Korea Scholar's Conference for Youth (KSCY), *Yonsei University*	2019

Teaching

*Best tutor award. †Graduate course.

Instructor

Quantum Complexity Reading Group, *Quantum Information Science Club Association*	†Fall 2025
[AAA559] College of Informatics Internship 2, *Korea University (external)*	†Fall 2025
[AAA558] College of Informatics Internship 1, *Korea University (external)*	†Fall 2025
Quantum Learning and Complexity Theory, *Quantum Information Science Club Association*	†Summer 2025
[SW4343] Software Field Placement 1, *Korea Aerospace University (external)*	Fall 2024

Teaching Assistant

[YCS1009] Change the World through Programming, *Yonsei University*	Fall 2022
[YCS1002] Software Programming, *Yonsei University*	Fall 2022
[EEE1108] Engineering Information Processing, *Yonsei University*	Fall 2021

Course Tutor

[MAT2016] Engineering Mathematics 3: Differential Equations and Linear Algebra, *Yonsei University*	*Spring 2022
[MAT1012] Engineering Mathematics 2: Multivariable and Vector Calculus, *Yonsei University*	*Fall 2021

Selected Talks

*Online talk.

Research Talks

"Efficient learning of bosonic Gaussian unitaries"

[Invited] Annual Meeting of the Quantum Information Society of Korea (QISK)	Feb. 2026 (Upcoming)
[Invited] N^3etFraST Workshop, *Korea Institute of Science & Technology Information (KISTI)*	Nov. 2025
[Invited] Quantum Data Science & AI (Q-DNA) Lab Seminar, *Yonsei University*	Nov. 2025
[Contributed] Annual Conference on Quantum Information Processing (QIP 2026)[(c)]	Jan. 2026 (Upcoming)

[(b)] Continuation of the undergraduate fellowship; recipients may extend the support for graduate study upon successful admission approval.

[(c)] Presented under the title *"Efficient Learning Algorithms for Structured Bosonic and Fermionic Unitary Operators"*, as a merged submission with arXiv:2504.11318.

"New aspects of quantum topological data analysis"
[Invited] KISTI-SNU Joint Workshop, *Daejeon KW Convention Center* Jun. 2025

"Resource-efficient algorithm for estimating the trace of quantum state powers"
[Invited] Quantum Computing Lab Seminar, *Electronics & Telecommunications Research Institute (ETRI)* Dec. 2024
[Invited] Quantum Information Theory Seminar (QST Seminar), *Seoul National University* *Dec. 2024
[Invited] IBM-Yonsei Qiskit Fall Fest, *Yonsei University* *Nov. 2024
[Invited] KISTI-KU-SNU Joint Workshop, *Seoul Biohub* Oct. 2024
[Contributed] Annual Meeting of Korean Mathematical Society (KMS), *Sungkyunkwan University* Oct. 2024
[Poster] Annual Conference on Quantum Information Processing (QIP 2025), *Raleigh Convention Center* Feb. 2025

"Mutual information maximizing quantum generative adversarial network"
[Invited] Triangle Quantum Computing Seminar, *NC State University Quantum Initiative* *Nov. 2023

"Estimating quantum mutual information through a quantum neural network"
[Invited] CS Katha Barta, *National Institute of Science Education and Research (NISER Bhubaneswar)* *Aug. 2023

"Quantum Rényi entropy functionals for bosonic Gaussian systems"
[Poster] Annual Conference on Quantum Information Processing (QIP 2022), *California Institute of Technology* Mar. 2022

"High-dimensional private quantum channels, ε-randomizing maps and regular polytopes"
[Invited] KISTI-KU-SNU Joint Workshop, *Virtual Conference* *Sep. 2023
[Invited] Quantum Information Theory Seminar (QST Seminar), *Seoul National University* *Aug. 2021
[Contributed] Winter Meeting of the Optical Society of Korea (OSK), *Daejeon Convention Center* Feb. 2022
[Contributed] Fall Meeting of the Korean Physical Society (KPS), *Virtual Conference* *Feb. 2022
[Poster] Annual Conference on Quantum Information Processing (QIP 2022), *California Institute of Technology* Mar. 2022

Tutorials and Lectures

"Learning theory in ∞-dimensional quantum systems"
[Invited] Team QST Summer Workshop, *Seoul National University* Aug. 2025

"Introduction to quantum machine learning"
[Invited] Healthcare & Research Team Seminar, *Amazon Web Services (AWS Korea)* Mar. 2025

"Topics in theoretical quantum computer science"
[Invited] Quantum Club Seminar, *Shinil High School* Aug. 2024

"Quantum machine learning models for drug library generation"
[Invited] Quantum Computing and Monte Carlo Workshop, *Yonsei University* Aug. 2024

"$\mathsf{QMA} \stackrel{?}{=} \mathsf{NP}$: The NLTS theorem and the quantum PCP conjecture"
[Invited] Center for Quantum Network's Channel Capacity Summer Workshop, *Seoul National University* Jul. 2024

"Minimal data may be sufficient for quantum artificial intelligence"
[Invited] Department of Mathematical Sciences Seminar, *Seoul National University* Jun. 2023

Research Projects

"Realizing Quantum Advantage in the Generation of Drug Library by Quantum Machine Learning" Apr. 2024 – Present
PI: Prof. Art Cho | *Sponsored by the National Research Foundation of Korea (NRF)* Role: Technical advising

"Quantum-Computing-Based Analysis on Vertical Dynamics of the Quarter Car Model" Sep. 2022 – Feb. 2023
PI: Prof. Soojoon Lee | *Sponsored by Hyundai NGV Tech Co., Ltd.* Role: Numerical simulation

"Determination of Qualitative Bounds for Quantum Channel Capacities and Quantum Algorithms" Mar. 2020 – Dec. 2022
PI: Dr. Kabgyun Jeong | *Sponsored by the National Research Foundation of Korea (NRF)* Role: Theoretical research

Skills and Technical Experience

Programming Languages: Proficient in C, C++, and Python; experienced with Java.

Quantum Software: Proficient in PennyLane and IBM Qiskit (certified); experienced with Q# and PyZX (ZX-calculus).
Certified Associate Developer (Quantum Computation using Qiskit), *IBM* 2023
Advanced Achievement, Quantum Spring Challenge, *IBM* 2023
Advanced Achievement, QHack Coding Challenges, *Xanadu Quantum Technologies* 2023

References

Prof. Soojoon Lee (Department of Mathematics, Kyung Hee University) level@khu.ac.kr
Prof. Daniel K. Park (Department of Applied Statistics, Yonsei University) dkd.park@yonsei.ac.kr
Dr. Kabgyun Jeong (Research Institute of Mathematics, Seoul National University) kgjeong6@snu.ac.kr
Dr. Marco Fanizza (Inria, Télécom Paris - LTCI, Institut Polytechnique de Paris) marco.fanizza@inria.fr