Junseo Lee

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Research Affiliate, Seoul National University | *Research Scientist*, Norma Inc.

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 Scholarship in Intelligent Information Technology* (2021–2022)
- High Honors (Top 3%, 2022); Honors (Top 10%, 2020–2021);

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

Research Interests

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

Research Experience

Research Institute of Mathematics (RIM), Seoul National University (SNU) Seoul, Korea
Research Affiliate, Quantum Information Theory Group (Team QST) Jan. 2023 – Present
Undergraduate Research Assistant (Advisor: Dr. Kabgyun Jeong) Mar. 2020 – Dec. 2022
- 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].
- 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.

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

Publications (Google Scholar Profile)

*Equal contribution. †Authors listed alphabetically.

Preprints

[14] M. Fanizza, V. Iyer, **J. Lee**†, A. A. Mele, F. A. Mele, "Efficient learning of bosonic Gaussian unitaries," arXiv:2510.05531. **QIP 2026** (*Contributed talk*, 29th Annual Conference on Quantum Information Processing).

[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] K. Anand, K. Jeong, **J. Lee**†, "Collapses in quantum-classical probabilistically checkable proofs and the quantum polynomial hierarchy," arXiv:2506.19792.

[11] **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).

[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).

[(a)] A designation under South Korea's Military Service Act for qualified scientists completing mandatory service through three years of full-time industry research.

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).

Working Papers

D. Ji, **J. Lee**†, A. Sawicki, O. Słowik, "Explicit bounds on polylogarithmic spectral gap decay in unitary channels," To appear.

J. Lee†, M. Shin, "Optimal certification of local Hamiltonians," To appear.

Selected Honors and Awards

Funding and Fellowships

PhD Study Abroad Fellowship[(b)] (partial funding), 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 Div.)	2016

Professional Activities

Journal Reviewer: Physical Review Letters, IEEE Transactions on Information Theory, npj Quantum Information, Physical Review Research, Physical Review Applied, Physical Review A, Physics Letters 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 Experience

*Best tutor award. †Graduate course.

Instructor

Quantum Learning Theory for Bosonic Systems, Quantum Information Science Club Association	†Winter 2025
Quantum Complexity Reading Group, Quantum Information Science Club Association	†Fall 2025
College of Informatics Internship, Korea University (external)	†Fall 2025
Quantum Learning and Complexity Theory, Quantum Information Science Club Association	†Summer 2025
Software Field Placement 1, Korea Aerospace University (external)	Fall 2024

Teaching Assistant

Change the World through Programming, Yonsei University	Fall 2022
Software Programming, Yonsei University	Fall 2022
Engineering Information Processing, Yonsei University	Fall 2021

Course Tutor

Engineering Mathematics 3 (Differential Equations and Linear Algebra), Yonsei University	*Spring 2022
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 2026)	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)], Riga	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 — 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), Caltech — 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), Caltech — 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

"QMA $\overset{?}{=}$ 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++ (Informatics Olympiad), 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