Junseo Lee

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Research Interests

Quantum Information and Theoretical Computer Science: Quantum Learning Theory, Quantum Complexity Theory, Quantum Property Testing, Quantum Algorithms, Bosonic Quantum Systems, and Quantum Shannon Theory

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); Honors (2020–2021); High Honors (2022)

Chungnam Science High School — Gongju, Korea
Mathematics Concentration, Early Graduation — Mar. 2017 – Dec. 2018

Research Experience

Professional Research Personnel (Alternative Military Service, 3-year national service program) — Seoul, Korea
Quantum Research Scientist (Theory), Norma Inc. — Jan. 2023 – Mar. 2026 (expected)
- Providing technical consulting on near-term quantum algorithms for industry- and government-funded projects
- Conducting theoretical research on quantum algorithms for topological data analysis [11, 13], and quantum generative adversarial networks [8]

Research Institute of Mathematics, 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
- Conducting research on quantum entropy inequalities [3, 4, 5], quantum nonlinear property estimation [6, 7, 9, 10], quantum polynomial hierarchy and proof systems [12], and quantum learning theory for continuous-variable systems [14]
- Mentoring four undergraduate research assistants, all of whom have co-authored publications
- Lecturing on quantum learning theory and quantum complexity theory for undergraduate and graduate students through the Quantum Information Science Club Association (see Teaching & Mentoring section)

Publications

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

Preprints

[15] (α-β) Dongwha Ji, **Junseo Lee**, Adam Sawicki, Oskar Slowik. "Optimal constants for spectral gap decay of random unitaries". (to appear).

[14] (α-β) Marco Fanizza, Vishnu Iyer, **Junseo Lee**, Antonio A. Mele, Francesco A. Mele. "Efficient learning of bosonic Gaussian unitaries". arXiv:2510.05531 (2025).

[13] Nhat A. Nghiem, **Junseo Lee**, Tzu-Chieh Wei. "Hybrid quantum-classical framework for Betti number estimation with applications to topological data analysis". arXiv:2508.01516 (2025).

[12] (α-β) Kartik Anand, Kabgyun Jeong, **Junseo Lee**. "Collapses in quantum-classical probabilistically checkable proofs and the quantum polynomial hierarchy". arXiv:2506.19792 (2025).

[11] (α-β) **Junseo Lee**, Nhat A. Nghiem. "New aspects of quantum topological data analysis: Betti number estimation, and testing and tracking of homology and cohomology classes". arXiv:2506.01432 (2025).

Journal Articles

[10] Donghwa Ji, **Junseo Lee**, Myeongjin Shin, IlKwon Sohn, Kabgyun Jeong. "Bounding quantum uncommon information with quantum neural estimators". Accepted in Quantum Science and Technology (2025).

[9] Myeongjin Shin*, **Junseo Lee***, Seungwoo Lee, Kabgyun Jeong. "Resource-efficient algorithm for estimating the trace of quantum state powers". Quantum **9**, 1832 (2025).

[8] Mingyu Lee, Myeongjin Shin, **Junseo Lee**, Kabgyun Jeong. "Mutual information maximizing quantum generative adversarial networks". Scientific Reports **15**, 32835 (2025).

[7] Myeongjin Shin*, Seungwoo Lee*, **Junseo Lee***, Donghwa Ji, Hyeonjun Yeo, Kabgyun Jeong. "Disentanglement provides a unified estimation for quantum entropies and distance measures". Physical Review A **110**, 062418 (2024).

[6] Myeongjin Shin, **Junseo Lee**, Kabgyun Jeong. "Estimating quantum mutual information through a quantum neural network". Quantum Information Processing **23**, 57 (2024).

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

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

[3] **Junseo Lee**, Kabgyun 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] Kabgyun Jeong, **Junseo Lee**, Jintae Choi, Seokmin Hong, Myunggu Jung, Gyeongbeom Kim, Jaekwon Kim, Suntaek Kim. "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] **Junseo 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. Mohammad Hammoudeh, Abdullah T. Alessa, Amro M. Sherbeeni, Clinton M. Firth, Abdullah S. Alessa). CRC Press (2024).

Conference Abstracts

Ju-Young Ryu*, **Junseo Lee***, Tak Hur, Daniel K. Park. "Quantum multiple kernel learning with entropy power inequalities". Quantum Techniques in Machine Learning (QTML) (2025). [Poster]

Patents

Kabgyun Jeong, Myeongjin Shin, **Junseo Lee**. "Method for estimating quantum mutual information through a quantum neural network". Korea Patent: App. No. 10-2024-0104765 (2024).

Selected Honors and Awards

Funding and Fellowships

PhD Study Abroad Fellowship, Hyundai Motor Chung Mong-Koo Foundation	2026 (expected)
Full-Tuition Scholarship and Stipend, Hyundai Motor Chung Mong-Koo Foundation	2021–2022
Academic Travel Grant (for QIP 2022, Caltech), Hyundai Motor Chung Mong-Koo Foundation	2022
Teaching Fellowship (for 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	2016

Professional Activities

Reviewing

Conference: QTML (2025)

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

Community Service

Creator and Maintainer, Quantum Learning Theory Zoo (curated database of quantum learning papers)	2025–present
Selection Committee, Quantum Internship Program, National Information Society Agency	2024–2025
Co-organizer, Quantum Information Theory Seminar (QST Seminar), Seoul National University	2024–2025
Co-organizer, Quantum AI Hackathon, Jeonju University	2025

Teaching & Mentoring

*Best tutor award. †Graduate course.

Instructor

Quantum Complexity Reading Group†, Quantum Information Science Club Association	Fall 2025
[AAA558, AAA559] College of Informatics Internship†, 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

Undergraduate Research Assistant Mentoring

Current: Myeongjin Shin (2023–, KAIST CS), Mingyu Lee (2023–, SNU CSE), Donghwa Ji (2024–, SNU Math)

Former: Kartik Anand (2025, IIT Goa CSE)

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 talk, Annual Meeting of the Quantum Information Society of Korea, Seoul, Korea — Feb. 2026 (upcoming)
- Invited talk, N^{3}etFraST, Korea Institute of Science and Technology Information (KISTI), Seoul, Korea — Nov. 2025
- Invited talk, Department of Applied Statistics and Data Science, Yonsei University, Seoul, Korea — Nov. 2025

"New aspects of quantum topological data analysis"
- Invited talk, KISTI-SNU Joint Workshop, Daejeon, Korea — Jun. 2025

"Resource-efficient algorithm for estimating the trace of quantum state powers"
- Invited talk, Electronics and Telecommunications Research Institute (ETRI), Daejeon, Korea — Dec. 2024
- Invited talk*, SNU QST Seminar, Seoul, Korea — Dec. 2024
- Invited talk*, IBM-Yonsei Qiskit Fall Fest, Seoul, Korea — Nov. 2024
- Invited talk, KISTI-KU-SNU Joint Workshop, Seoul, Korea — Oct. 2024
- Contributed talk, Annual Meeting of Korean Mathematical Society, Suwon, Korea — Oct. 2024
- Poster presentation, QIP 2025, Raleigh, NC, USA — Feb. 2025

"Mutual information maximizing quantum generative adversarial network"
- Invited talk*, Triangle Quantum Computing Seminar, North Carolina State, Raleigh, NC, USA — Nov. 2023

"Estimating quantum mutual information through a quantum neural network"
- Invited talk*, CS Katha Barta, National Institute of Science Education and Research, Bhubaneswar, India — Aug. 2023

"Quantum Rényi entropy functionals for bosonic Gaussian systems"
- Poster presentation, QIP 2022, Pasadena, CA, USA — Mar. 2022

"High-dimensional private quantum channels, ε-randomizing maps and regular polytopes"
- Invited talk*, KISTI-KU-SNU Joint Workshop, Seoul, Korea — Sep. 2023
- Invited talk*, SNU QST Seminar, Seoul, Korea — Aug. 2021
- Contributed talk, Winter Meeting of the Optical Society of Korea, Daejeon, Korea — Feb. 2022
- Contributed talk*, Fall Meeting of the Korean Physical Society, Korea — Feb. 2022
- Poster presentation, QIP 2022, Pasadena, CA, USA — Mar. 2022

Invited Academic Talks and Lectures

"Introduction to quantum machine learning"
- Invited lecture, AWS Healthcare & Research Team, Seoul, Korea — Mar. 2025

"Topics in theoretical quantum computer science"
- Invited lecture, Shinil High School, Seoul, Korea — Aug. 2024

"Quantum machine learning models for drug library generation"
- Invited talk, Yonsei Quantum Computing and Monte Carlo Workshop, Chuncheon, Korea — Aug. 2024

"QMA $\stackrel{?}{=}$ NP: The NLTS theorem and the quantum PCP conjecture"
- Invited talk, Center for Quantum Network's Channel Capacity Summer Workshop, Seoul, Korea — Jul. 2024

"Minimal data may be sufficient for quantum artificial intelligence"
- Invited talk, Department of Mathematical Sciences, Seoul National University, Seoul, Korea — Jun. 2023

Certifications

- Advanced Achievement, Quantum Spring Challenge, IBM — 2023
- Advanced Achievement, QHack Coding Challenges, Xanadu Quantum Technologies — 2023
- Certified Associate Developer (Quantum Computation using Qiskit), IBM — 2023
- Advanced Data Analytics Semi-Professional, Korea Data Agency — 2023

(Last updated: October 20, 2025)