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, Continuous-Variable 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); *Semester 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

Professional Research Personnel (Alternative Military Service, *3-year national service program*) *Seoul, Korea*
Quantum Research Scientist (Theory), Norma Inc. Jan. 2023 – Present
- Provided technical consulting on quantum software and near-term algorithms for industry and government projects.
- Conducted theoretical and numerical research on quantum algorithms for topological data analysis [11, 13] and on hybrid quantum–classical machine learning [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
- 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 continuous-variable systems [14].
- Collaborated with international research groups at Inria Paris, UT Austin, FU Berlin, SNS Pisa, Stony Brook University, and the Center for Theoretical Physics of the Polish Academy of Sciences.
- Delivered lectures on quantum learning and complexity theory to undergraduate and graduate students.

Publications

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

Preprints

[15] $(\alpha\text{-}\beta)$ Dongwha Ji, **Junseo Lee**, Adam Sawicki, Oskar Slowik. "Explicit bounds on polylogarithmic spectral gap decay in unitary channels". (to appear).

[14] $(\alpha\text{-}\beta)$ 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] $(\alpha\text{-}\beta)$ Kartik Anand, Kabgyun Jeong, **Junseo Lee**. "Collapses in quantum-classical probabilistically checkable proofs and the quantum polynomial hierarchy". arXiv:2506.19792 (2025).

[11] $(\alpha\text{-}\beta)$ **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).

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)
↳ Continuation of the undergraduate fellowship upon selection approval
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* — 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)

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
[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

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

Undergraduate Research Assistant Mentoring at RIM, SNU

Current: Myeongjin Shin (2023–, KAIST CS), Mingyu Lee (2023–, SNU CSE), Donghwa Ji (2024–, SNU Math)
Former: Kartik Anand (2025, IIT Goa CSE)

Selected Talks

*Online talk.

Research Talks

"Efficient learning of bosonic Gaussian unitaries"
[Invited] Annual Meeting of the Quantum Information Society of Korea (QISK), *Seoul, Korea* Feb. 2026 (Upcoming)
[Invited] N^{3}etFraST Workshop, organized by *Korea Institute of Science & Technology Information*, *Seoul, Korea* Nov. 2025
[Invited] Quantum Data Science & AI (Q-DNA) Lab Seminar, *Yonsei University, Seoul, Korea* Nov. 2025

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

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

"Mutual information maximizing quantum generative adversarial network"
[Invited] Triangle Quantum Computing Seminar, *UNC Kenan-Flagler's Rethinc. Labs, Raleigh, NC, USA* *Nov. 2023

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

"Quantum Rényi entropy functionals for bosonic Gaussian systems"
[Poster] Annual Quantum Information Processing Conference (QIP 2022), *Pasadena, CA, USA* Mar. 2022

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

Tutorials and Lectures

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

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

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

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

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

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.
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

Relevant Advanced Coursework: Quantum Machine Learning, Introduction to Quantum Information Theory, Algebraic Geometry, Elementary Particle Physics, Probability and Random Variables, Mathematics for Electrical Engineers (Convex Optimization), Introduction Artificial Intelligence, Game Theory and Applications, Control Engineering

(Last updated: October 24, 2025)