

# 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<sup>(a)</sup>, 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

<sup>(α-β)</sup> Authors listed alphabetically (theoretical computer science convention). \*Equal contribution.

### Preprints

- [15] <sup>(α-β)</sup> D. Ji, **J. Lee**, A. Sawicki, O. Slowik. Explicit bounds on polylogarithmic spectral gap decay in unitary channels.
- [14] <sup>(α-β)</sup> 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] <sup>(α-β)</sup> K. Anand, K. Jeong, **J. Lee**. Collapses in quantum-classical probabilistically checkable proofs and the quantum polynomial hierarchy. [arXiv:2506.19792](#).
- [11] <sup>(α-β)</sup> **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).

<sup>(a)</sup>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

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

#### Additional Honors and Awards

Best Tutor Award, <i>Innovation Center for Teaching and Learning, Yonsei University</i>	2021–2022
Selected Paper Award, <i>Finance and Economics Contest, DB Group</i>	2022
Outstanding Translator Award (with Travel Prize), <i>NAVER Connect Foundation and Khan Academy</i>	2018
Gold Award (Regional), Honorable Mention (National), <i>Korean Olympiad in Informatics (Middle School Division)</i>	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, <i>Quantum Learning Theory Zoo</i> ( <i>curated database of quantum learning papers</i> )	2025–Present
Selection Committee, <i>Quantum Internship Program</i> , organized by <i>National Information Society Agency</i>	2024–2025
Co-organizer, <i>Quantum Information Theory Seminar (QST Seminar)</i> , <i>Seoul National University</i>	2024–2025
Co-organizer, <i>Quantum AI Hackathon</i> , jointly organized by <i>Kakao Enterprise Corp.</i> , and <i>Jeonju University</i>	2025
Facilitator (Mentor), Mathematics Section, <i>Korea Scholar's Conference for Youth (KSCY)</i> , <i>Yonsei University</i>	2019

### Teaching

\* Best tutor award. † Graduate course.

#### Instructor

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

#### Teaching Assistant

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

#### Course Tutor

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

### Selected Talks

\* Online talk.

#### Research Talks

"Efficient learning of bosonic Gaussian unitaries"

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

<sup>(b)</sup>Continuation of the undergraduate fellowship; recipients may extend the support for graduate study upon successful admission approval.

<sup>(c)</sup>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, <i>Daejeon KW Convention Center</i>		Jun. 2025
"Resource-efficient algorithm for estimating the trace of quantum state powers"		
[Invited] Quantum Computing Lab Seminar, <i>Electronics &amp; Telecommunications Research Institute (ETRI)</i>		Dec. 2024
[Invited] <a href="#">Quantum Information Theory Seminar (QST Seminar), Seoul National University</a>		*Dec. 2024
[Invited] <a href="#">IBM-Yonsei Qiskit Fall Fest, Yonsei University</a>		*Nov. 2024
[Invited] KISTI-KU-SNU Joint Workshop, <i>Seoul Biohub</i>		Oct. 2024
[Contributed] Annual Meeting of Korean Mathematical Society (KMS), <i>Sungkyunkwan University</i>		Oct. 2024
[Poster] Annual Conference on Quantum Information Processing (QIP 2025), <i>Raleigh Convention Center</i>		Feb. 2025
"Mutual information maximizing quantum generative adversarial network"		
[Invited] <a href="#">Triangle Quantum Computing Seminar, NC State University Quantum Initiative</a>		*Nov. 2023
"Estimating quantum mutual information through a quantum neural network"		
[Invited] <a href="#">CS Katha Barta, National Institute of Science Education and Research (NISER) Bhubaneswar</a>		*Aug. 2023
"Quantum Rényi entropy functionals for bosonic Gaussian systems"		
[Poster] Annual Conference on Quantum Information Processing (QIP 2022), <i>California Institute of Technology</i>		Mar. 2022
"High-dimensional private quantum channels, $\epsilon$ -randomizing maps and regular polytopes"		
[Invited] KISTI-KU-SNU Joint Workshop, <i>Virtual Conference</i>		*Sep. 2023
[Invited] <a href="#">Quantum Information Theory Seminar (QST Seminar), Seoul National University</a>		*Aug. 2021
[Contributed] Winter Meeting of the Optical Society of Korea (OSK), <i>Daejeon Convention Center</i>		Feb. 2022
[Contributed] Fall Meeting of the Korean Physical Society (KPS), <i>Virtual Conference</i>		*Feb. 2022
[Poster] Annual Conference on Quantum Information Processing (QIP 2022), <i>California Institute of Technology</i>		Mar. 2022

## Tutorials and Lectures

"Learning theory in $\infty$ -dimensional quantum systems"		
[Invited] Team QST Summer Workshop, <i>Seoul National University</i>		Aug. 2025
"Introduction to quantum machine learning"		
[Invited] Healthcare & Research Team Seminar, <i>Amazon Web Services (AWS), Korea</i>		Mar. 2025
"Topics in theoretical quantum computer science"		
[Invited] Quantum Club Seminar, <i>Shinil High School</i>		Aug. 2024
"Quantum machine learning models for drug library generation"		
[Invited] Quantum Computing and Monte Carlo Workshop, <i>Yonsei University</i>		Aug. 2024
"QMA $\stackrel{?}{=}$ NP: The NLTS theorem and the quantum PCP conjecture"		
[Invited] Center for Quantum Network's Channel Capacity Summer Workshop, <i>Seoul National University</i>		Jul. 2024
"Minimal data may be sufficient for quantum artificial intelligence"		
[Invited] <a href="#">Department of Mathematical Sciences Seminar, Seoul National University</a>		Jun. 2023

## Research Projects

"Realizing Quantum Advantage in the Generation of Drug Library by Quantum Machine Learning"	Apr. 2024 – Present
PI: Prof. Art Cho   <a href="#">Sponsored by the National Research Foundation of Korea (NRF)</a>	Role: Technical advising
"Quantum-Computing-Based Analysis on Vertical Dynamics of the Quarter Car Model"	Sep. 2022 – Feb. 2023
PI: <a href="#">Prof. Soojoon Lee</a>   <a href="#">Sponsored by Hyundai NGV Tech Co., Ltd.</a>	Role: Numerical simulation
"Determination of Qualitative Bounds for Quantum Channel Capacities and Quantum Algorithms"	Mar. 2020 – Dec. 2022
PI: <a href="#">Dr. Kabgyun Jeong</a>   <a href="#">Sponsored by the National Research Foundation of Korea (NRF)</a>	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

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