Junseo Lee

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Research Interests

Theoretical Aspects of Quantum Computation
Quantum Learning Theory, Quantum Complexity Theory, Quantum Shannon Theory, and Quantum Algorithms

Education

Yonsei University — *Seoul, Korea*
Bachelor of Science in Electrical and Electronic Engineering — *March 2019 – February 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 Major, *Early Graduation for Top 20% Students* — *March 2017 – December 2018*

Research Experience

Professional Research Personnel* **(Alternative Military Service)** — *Seoul, Korea*
Quantum Research Scientist (Theory), Norma Inc. — ****3-year mandatory national service*** — *January 2023 – present*
- Conducting research on quantum algorithms for problems in topological data analysis and matrix algebra
- Providing technical consulting on near-term quantum algorithms for industry- and government-funded projects

Research Institute of Mathematics, Seoul National University — *Seoul, Korea*
Research Associate (Quantum Information Theory Group) — *January 2023 – present*
Research Assistant (Advisor: Kabgyun Jeong) — *March 2020 – December 2022*
- Conducting research in quantum learning theory, quantum complexity theory, and quantum Shannon theory, with a focus on quantum property estimation, quantum proof systems, and quantum entropy functionals.

Publications

Google Scholar Profile ORCiD (0000-0003-4858-2663)

Preprints (Submitted) — $^{(\alpha\text{-}\beta)}$*Alphabetical order (theoretical computer science convention).* **Equal contribution.*

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

[12] Bounding quantum uncommon information with quantum neural estimators
Donghwa Ji, **Junseo Lee**, Myeongjin Shin, IlKwon Sohn, Kabgyun Jeong — *arXiv:2507.06091* (2025).

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

[10] New aspects of quantum topological data analysis: Betti number estimation, and testing and tracking of homology and cohomology classes
Junseo Lee$^{(\alpha\text{-}\beta)}$, Nhat A. Nghiem — *arXiv:2506.01432* (2025).

[9] Mutual information maximizing quantum generative adversarial networks
Mingyu Lee, Myeongjin Shin, **Junseo Lee**, Kabgyun Jeong — *arXiv:2309.01363* (2023).

Journal Articles

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

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

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

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

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

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

[2] Single qubit private quantum channels and 3-dimensional regular polyhedra
Kabgyun Jeong, **Junseo Lee**, Jintae Choi, Seokmin Hong, Myunggu Jung, Gyeongbeom Kim, Jaekwon Kim, Suntaek Kim *Bronze Award, The Humantech Paper Award, Samsung Electronics* (2018).
New Physics: Sae Mulli **68**, 232 (2018).

Book Chapters

[1] Quantum computing: A journey into the next frontier of information and communication security
edited by Mohammad Hammoudeh, Abdullah T. Alessa, Amro M. Sherbeeni, Clinton M. Firth, Abdullah S. Alessa
Junseo Lee, §11 Assessing Quantum Integer Factorization Performance with Shor's Algorithm *CRC Press* (2024).

Conference Abstracts

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

Patents

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

Working Papers* **The collaborators' names are listed in alphabetical order.*

Learning bosonic Gaussian unitaries (with Marco Fanizza, Vishnu Iyer, Antonio A. Mele, Francesco A. Mele)

Classical oracle separation of QMA and its unique variant (with Kartik Anand)

Tight bounds on estimating trace of quantum state powers from incoherent measurements (with Angus Lowe, Chirag Wadhwa, Qisheng Wang)

Professional Activities

Peer Reviewing

Conference: QTML 2025
Journals: Physical Review Letters, Physical Review A, Physical Review Applied, IEEE Transactions on Information Theory, Annalen der Physik

Community Service

Selection Committee, Quantum Internship Program, *National Information Society Agency* *2024–2025*
Co-organizer, Problem Writer, and Judge, Quantum AI Hackathon, *Jeonju University* *2025*
Co-organizer, Quantum Information Theory Seminar (QST Seminar), *Seoul National University* *2024–2025*

Selected Honors and Awards

Funding and Fellowships

PhD Study Abroad Fellowship, *Hyundai Motor Chung Mong-Koo Foundation* *2026–TBD*
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*
Excellent Translator Award, *NAVER Connect Foundation and Khan Academy* *2018*
Gold Award (Regional), Honorable Mention (National), Korean Olympiad in Informatics *2016*

Certifications and Achievements

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

Selected Talks*

*A complete list of talks is available at harris-junseo-lee.github.io/talks. †Online talk

Research Talks

New aspects of quantum topological data analysis
Invited talk, *KISTI-SNU Joint Workshop, Daejeon, Korea* — *June 2025*

Resource-efficient algorithm for estimating the trace of quantum state powers
Invited talk, *Electronics and Telecommunications Research Institute, Daejeon, Korea* — *December 2024*
Invited talk, *Seoul National University, Seoul, Korea* — *December 2024*
Invited talk, *IBM-Yonsei Qiskit Fall Fest*, *Seoul, Korea* — *November 2024*
Invited talk, *KISTI-KU-SNU Joint Workshop, Seoul, Korea* — *October 2024*
Contributed talk, *Korean Mathematical Society, Suwon, Korea* — *October 2024*
Poster presentation, *QIP 2025, Raleigh, NC, USA* — *February 2025*

Mutual information maximizing quantum generative adversarial network
Invited talk†, *Triangle Quantum Computing Seminar*, *North Carolina State, Raleigh, NC, USA* — *November 2023*

Estimating quantum mutual information through a quantum neural network
Invited talk†, *National Institute of Science Education and Research, Bhubaneswar, India* — *August 2023*

Quantum Rényi entropy functionals for bosonic Gaussian systems
Poster presentation, *QIP 2022, Pasadena, CA, USA* — *March 2022*

Invited Academic Talks

Introduction to quantum machine learning
Invited lecture, *AWS Healthcare & Research Team, Seoul, Korea* — *March 2025*

Topics in theoretical quantum computer science
Invited lecture, *Shinil High School, Seoul, Korea* — *August 2024*

Quantum machine learning models for drug library generation
Invited talk, *Yonsei Quantum Computing and Monte Carlo Workshop, Chuncheon, Korea* — *August 2024*

The NLTS theorem and the quantum PCP conjecture
Invited talk, *Center for Quantum Network's Channel Capacity Summer Workshop, Seoul, Korea* — *July 2024*

Teaching Experience

*Best tutor award

Instructor

College of Informatics Internship 2 (AAA559, external), *Korea University (Graduate)* — *Fall 2025*
College of Informatics Internship 1 (AAA558, external), *Korea University (Graduate)* — *Fall 2025*
Quantum Learning and Complexity Theory, *QISCA Summer School (Graduate and Undergraduate)* — *Summer 2025*
Software Field Placement 1 (SW4343, external), *Korea Aerospace University (Undergraduate)* — *Fall 2024*

Teaching Assistant

Change the World through Programming (YCS1009), *Yonsei University (Undergraduate)* — *Fall 2022*
Software Programming (YCS1002), *Yonsei University (Undergraduate)* — *Fall 2022*
Engineering Information Processing (EEE1108), *Yonsei University (Undergraduate)* — *Fall 2021*

Course Tutor

EM 3: Differential Equations and Linear Algebra (MAT2016), *Yonsei University (Undergraduate)* — *Spring 2022**
EM 2: Multivariable and Vector Calculus (MAT1012), *Yonsei University (Undergraduate)* — *Fall 2021**