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 — *March 2019 – February 2023*
Thesis: Combinatorial Designs for Information Theory
Fully funded by the *Hyundai Motor 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 topological data analysis and matrix problems
- Providing technical consulting on near-term quantum algorithms for industry and government-funded projects

Research Institute of Mathematics, Seoul National University — Seoul, Korea
Research Fellow (Quantum Information Theory Group, Advisor: Kabgyun Jeong) — *March 2020 – present*
- 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* (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 (1st ed.)
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 — *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 t-doped bosonic Gaussian unitaries
(with Marco Fanizza, Vishnu Iyer, Antonio Anna Mele, Francesco Anna Mele)

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

Optimal constants for spectral gap decay in the space of unitary channels
(with Donghwa Ji, Adam Sawicki, Oskar Słowik)

Professional Activities

Peer Reviewing

Journals: Physical Review Letters, Physical Review A, Physical Review Applied, IEEE Transactions on Information Theory, Annalen der Physik
Conference: Quantum Techniques in Machine Learning (QTML 2025)

Community Service

Selection Committee, Quantum Internship Program, National Information Society Agency — *2024–2025*
Co-organizer, Quantum AI Hackathon — *2025*
Co-organizer, SNU Quantum Information Theory Seminar (QST Seminar) — *2024–2025*

Selected Honors and Awards

Funding and Fellowships

PhD Study Abroad Fellowship, Hyundai Motor Foundation — *2026–TBD*
Full-Tuition Scholarship and Stipend, Hyundai Motor Foundation — *2021–2022*
Academic Travel Grant (for QIP 2022, Caltech), Hyundai Motor 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 — *2018*
Awarded for translating Khan Academy's Calculus and General Chemistry courses into Korean
Gold Award, Korean Olympiad in Informatics, Regional Qualifiers — *2016*

Certifications and Achievements

Advanced Achievement, IBM Quantum Spring Challenge — *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.

Research Talks

New aspects of quantum topological data analysis
- Invited talk at the 5th KISTI-SNU Joint Workshop — *June 2025*

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

Disentanglement provides a unified estimation for quantum entropies and distance measures
- Contributed talk at the Korean Physical Society — *April 2024*
- Contributed talk at the Quantum Information Society of Korea — *April 2024*
- Poster presentation at QIP 2024 — *January 2024*

Mutual information maximizing quantum generative adversarial network
- Invited talk at North Carolina State University Triangle Quantum Computing Seminar — *November 2023*
- Poster presentation at QIP 2024 — *January 2024*

Estimating quantum mutual information through a quantum neural network
- Invited talk at National Institute of Science Education and Research Bhubaneswar India — *August 2023*
- Poster presentation at TQC 2023 — *July 2023*

Quantum Rényi entropy functionals for bosonic gaussian systems
- Contributed talk at the Korean Society for Industrial and Applied Mathematics — *December 2021*
- Poster presentation at QIP 2022 — *March 2022*

Invited Lectures

Introduction to quantum machine learning
- Invited lecture at AWS Healthcare & Research Team — *March 2025*

Topics in theoretical quantum computer science
- Invited lecture at Shinil High School — *August 2024*

Teaching Experience

*Best Tutor Award

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

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

Course Tutor
- Engineering Mathematics III: Linear Algebra and Differential Equations (MAT2016), Yonsei* — *Spring 2022*
- Engineering Mathematics II: Multivariable and Vector Calculus (MAT1012), Yonsei* — *Fall 2021*