

Akira Sone

E-mail: akira.sone@umb.edu

Phone: +1-617-287-6044

Homepage: <https://blogs.umb.edu/akirasone/>

Career interests

My research interests lie in broad areas in quantum information theory, quantum optics and nonequilibrium statistical mechanics. Particularly, I am interested in the quantum machine learning, quantum thermodynamics, quantum metrology, and quantum communication, and quantum physics education.

Education

Massachusetts Institute of Technology, Cambridge, MA, USA. (September 3, 2013 ~ June 6, 2019)

Ph.D. in Quantum Engineering (2019), Department of Nuclear Science and Engineering;

Thesis: “Quantum system identification by local measurements”

Supervisor: Prof. Paola Cappellaro

Keio University, Hiyoshi, Kanagawa, Japan (April 1, 2009 ~ Mar 10, 2013)

Bachelor degree in Engineering (2013), Department of Applied Physics and Physico-Informatics

Thesis: “Entanglement distribution in an open quantum system” (Best bachelor thesis prize)

Supervisor: Prof. Naoki Yamamoto

Work experience

University of Massachusetts Boston, Boston, MA, USA. (September 1, 2022 ~ present)

Assistant Professor;

Department of Physics

Aliro Technologies, Inc, Boston, MA, USA. (January 18, 2021 ~ August 31, 2022)

Research Software Engineer;

Supervisor: Prof. Prineha Narang (currently the professor at University of California, Los Angeles)

Los Alamos National Laboratory, Los Alamos, NM, USA. (September 16, 2019 ~ January 15, 2021)

Postdoctoral Research Associate;

Theoretical division and Center for Nonlinear Studies

Supervisor: Dr. Patrick J. Coles (currently the chief scientist at Normal Computing)

Massachusetts Institute of Technology, Cambridge, MA, USA. (August 12, 2019 ~ September. 07, 2019)

Project Assistant (equivalent to Postdoctoral Scholar);

Research Laboratory of Electronics

Supervisor: Prof. Paola Cappellaro

Massachusetts Institute of Technology, Cambridge, MA, USA. (September 3, 2013 ~ June 7, 2019)

Research and Teaching Assistant;

Department of Nuclear Science and Engineering and Research Laboratory of Electronics

Supervisor: Prof. Paola Cappellaro

Grants

Award Year	Organization / Grant No.	Amount	Role	Start date and End date
2023	NSF/MPS-2328774	\$5,000,000.00	Co-PI	10/01/2023 ~ 09/30/2028

2024	NSF/PHY-2425180	\$900,000.00	Co-PI	08/15/2024 ~ 07/31/2027
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Publications (* denotes “equally contributed”)

1. **Akira Sone**, Diogo O. Soares-Pinto, and Sebastian Deffner, “Conditional quantum thermometry – enhancing precision by measuring less”, [Quantum Sci. Technol. 9 045018](#) (2024)
2. **Akira Sone**, Akira Tanji and Noaki Yamamoto, “Quantum Inception Score”, [Phys. Rev. Research 6, 033198](#) (2024)
3. Zidong Cui, Shan Jin, **Akira Sone**, and Xiaoting Wang, “Achieving quantum advantages for image filtering”, [Sci. China Phys. Mech. Astron. 67, 290362](#) (2024)
4. Kenji Maeda, Tharon Holdsworth, Sebastian Deffner and **Akira Sone**, “Detailed fluctuation theorem from one-time measurement scheme”, [Phys. Rev. A 108, L050203](#) (2023)
5. **Akira Sone**, Kanu Sinha, and Sebastian Deffner, “Thermodynamic perspective on quantum fluctuations”, [arXiv: 2308.04951](#) (2023)
6. **Akira Sone**, Diogo O. Soares-Pinto, and Sebastian Deffner, “Exchange fluctuation theorems for strongly interacting quantum pumps”, [AVS Quantum Sci. 5, 032001](#) (2023)
7. **Akira Sone**, Naoki Yamamoto, Tharon Holdsworth, and Prineha Narang, “Jarzynski-like Equality of Nonequilibrium Information Production Based on Quantum Cross Entropy”, [Phys. Rev. Research 5, 023039](#) (2023)
8. C. Huerta Aldereta, Max Hunter Gordon, Frederic Sauvage, **Akira Sone**, Andrew T. Sornborger, Patrick J. Coles, M. Cerezo, “Inference-Based Quantum Sensing”, [Phys. Rev. Lett. 129, 190501](#) (2022)
9. Bingzhi Zhang, **Akira Sone**, and Quntao Zhuang, “Quantum Computational Phase Transition in Combinatorial Problems”, [npj Quantum Inf. 8, 87](#) (2022)
10. Jacob L. Beckey, M. Cerezo, **Akira Sone**, Patrick J. Coles, “Variational quantum algorithm for estimating the quantum Fisher information”, [Phys. Rev. Research 4, 013083](#) (2022)
11. **Akira Sone***, M. Cerezo*, Jacob L. Beckey, and Patrick J. Coles, “Generalized Measure of Quantum Fisher Information”, [Phys. Rev. A 104, 062602](#) (2021)
12. Samson Wang, Enrico Fontana, M. Cerezo, Kunal Sharma, **Akira Sone**, Lukasz Cincio and Patrick J. Coles, “Noise-Induced Barren Plateaus in Variational Quantum Algorithms”, [Nat. Commun. 12, 6961](#) (2021)
13. **Akira Sone** and Sebastian Deffner, “Jarzynski equality for conditional stochastic work”, [J. Stat. Phys 183, 11](#) (2021)
14. M. Cerezo, **Akira Sone**, Tyler Volkoff, Lukasz Cincio and Patrick J. Coles, “Cost function dependent barren plateaus in shallow parameterized quantum circuits”, [Nat. Commun. 12, 1791](#) (2021)

15. **Akira Sone** and Sebastian Deffner, “Quantum and classical ergotropy from relative entropies”, [Entropy](#) **23**, 1107 (2021)
16. M. Cerezo*, **Akira Sone***, Jacob L. Beckey, and Patrick J. Coles, “Sub-Quantum Fisher Information”, [Quantum Sci. Technol.](#) **6** 035008 (2021)
17. **Akira Sone**, Yi-Xiang Liu, and Paola Cappellaro, “Quantum Jarzynski Equality of Open Quantum Systems in One-Time Measurement Scheme”, [Phys. Rev. Lett.](#) **125**, 060602 (2020)
18. Yuanlong Wang, Daoyi Dong, **Akira Sone**, Ian Petersen, Hidehiro Yonezawa, Paola Cappellaro, “Quantum Hamiltonian Identifiability via Similarity Transformation Approach and Beyond”, [IEEE Trans. Autom. Control.](#) **65**, 4632 (2020)
19. **Akira Sone**, Quntao Zhuang, Changhao Li, Yi-Xiang Liu and Paola Cappellaro, “Nonclassical correlations for quantum metrology in thermal equilibrium”, [Phys. Rev. A](#) **99**, 052318 (2019)
20. **Akira Sone***, Quntao Zhuang*, and Paola Cappellaro, “Quantifying precision loss in local quantum thermometry via diagonal discord”, [Phys. Rev. A](#) **98**, 012115 (2018)
21. **Akira Sone** and Paola Cappellaro, “Exact dimension estimation of interacting qubit systems assisted by a single quantum probe”, [Phys. Rev. A](#) **96**, 062334 (2017)
22. **Akira Sone** and Paola Cappellaro, “Hamiltonian identifiability assisted by a single-probe measurement”, [Phys. Rev. A](#) **95**, 022335 (2017)

Technical and invited talks

1. **Akira Sone**, “Exploring Quantum Generative Models from Quantum Communication Perspective”, invited talk at **63rd Sanibel Symposium** organized by **University of Florida**, St. Augustine Beach, FL, USA, March 2024
2. **Akira Sone**, “Reliability and Practicability of Noisy Intermediate-Scale Quantum Computers”, invited talk at Physics Colloquium at **University of Rhode Island**, Kingston, RI, USA, April 2023
3. **Akira Sone**, “Near-term Quantum Algorithms and Its Applications”, invited talk at Quantum Materials and Devices Seminar at **Harvard University**, Cambridge, MA, USA, February 2023
4. **Akira Sone**, “Near-term Quantum Computer and Its Application”, invited by Prof. Junko Ishi-Hayase at **Keio University**, Yokohama, Kanagawa, Japan, February 2023 (Virtual in Japanese).
5. **Akira Sone**, “Heat Exchange of Multipartite Quantum Systems”, Physics Colloquium at **University of Massachusetts Boston**, MA, USA, February 2023
6. **Akira Sone**, “Near-term Quantum Algorithms and Its Applications”, invited by Dr. Jian Feng Kong at **Institute of High-Performance Computing**, Singapore, January 2023 (Virtual)
7. **Akira Sone**, “Computational Phase Transition of Quantum Approximate Optimization Algorithms”, invited by Prof. Takahiro Sagawa at **University of Tokyo**, Hongo, Tokyo, Japan, October 2022 (Virtual)

8. **Akira Sone**, “Quantum Correlations in Heat Exchange of Multipartite Quantum Systems”, Physics Colloquium at [University of Maryland Baltimore County](#), Baltimore, MD, USA, October 2022
9. **Akira Sone**, “Toward Practical Near-term Quantum Computers”, Physics Colloquium at [University of Rochester](#), Rochester, NY, USA, March 2022
10. **Akira Sone**, “Noisy Intermediate-Scale Quantum Computer and Its Applications”, Electrical and Computer Engineering Colloquium at [University of Arizona](#), Tucson, AR, USA, March 2022
11. **Akira Sone**, “Variational Quantum Algorithms for Quantum Sensing”, invited by Prof. Clarice Aiello at [University of California, Los Angeles](#), Los Angeles, CA, USA, February 2022
12. **Akira Sone**, “Toward Practical Near-term Quantum Computers”, Physics Colloquium at [University of Arizona](#), Tucson, AR, USA, February 2022 (Virtual)
13. **Akira Sone**, “Toward Practical Near-term Quantum Computers”, Physics Colloquium at [University of Massachusetts, Boston](#), Boston, MA, USA, February 2022
14. **Akira Sone**, “Toward Practical Near-term Quantum Computers”, Physics Colloquium at [University of Alabama at Birmingham](#), Birmingham, AL, USA, February 2022
15. **Akira Sone**, “Toward Practical Near-term Quantum Computers”, Physics Colloquium at [University of South Florida](#), Tampa, FL, USA, February 2022
16. **Akira Sone**, “Dialogue with Nature through Quantum Information”, Electrical and Computer Engineering Colloquium at [New Mexico State University](#), Las Cruces, NM, USA, September 2021 (Virtual)
17. **Akira Sone**, “Near-term Quantum Computer for Quantum Metrology”, Theoretical Physics Seminar at [University of Massachusetts, Lowell](#), Lowell MA, USA, September 2021
18. **Akira Sone**, “Quantum Metrology assisted by Noisy Intermediate-Scale Quantum Computers”, invited by Prof. Paola Cappellaro at [Massachusetts Institute of Technology](#), Cambridge MA, USA, September 2021
19. **Akira Sone**, M. Cerezo, Jacob L. Beckey, and Patrick J. Coles, “Variational Quantum Algorithms for Estimating the Quantum Fisher Information”, invited by [Quantum Science Center](#), Oak Ridge TN, USA, October 2020
20. **Akira Sone**, “Quantum Jarzynski Equality of Open Quantum Systems”, invited by Prof. Howard Wiseman at [Griffith University](#), Brisbane, Australia, October 2020 (Virtual)
21. **Akira Sone**, “Quantum system identification by local measurement”, invited by Prof. Christopher Monroe at [University of Maryland, College Park](#), College Park, MD, USA, May 2019
22. **Akira Sone**, “Quantum system identification assisted by local measurement”, invited by Prof. Hersch Rabitz at [Princeton University](#), Princeton, NJ, USA, November 2018
23. **Akira Sone**, “Quantum system identification assisted by local measurement”, invited by Prof. Christopher Jarzynski at [University of Maryland, College Park](#), College Park, MD, USA, October 2018

24. **Akira Sone**, “Quantum system identification with a single quantum sensor”, invited by Prof. Daoyi Dong, Prof. Ian Petersen, and Prof. Matthew James at [New South Wales University and Australia National University](#), Canberra, Australia, August 2017
25. **Akira Sone**, “Quantum system identification assisted by single-probe measurement”, [MIT Center for Ultracold Atoms \(CUA\) Retreat](#), Plymouth, NH, USA, January 2017

Conference / Workshop presentations

1. **Akira Sone**, “Physical Advantage and Limitation of Quantum Generative Models”, [2024 Quantum Thermodynamics Conference \(QTD2024\)](#), College Park, Maryland, USA, August 2024
2. Kenji Maeda, Takuya Isogawa, Santiago Hernández-Gomez, Sebastian Deffner, Paola Cappellaro, and **Akira Sone**, “Quantum Process Discrimination by Quantum Fluctuation Theorems”, [2024 Quantum Thermodynamics Conference \(QTD2024\)](#), College Park, Maryland, USA, August 2024
3. Shou-I Tang, Akram Touil, Sebastian Deffner, and Akira Sone, “Quantum Thermodynamic Speed Limit” (poster presentation), [2024 Quantum Thermodynamics Conference \(QTD2024\)](#), College Park, Maryland, USA, August 2024
4. **Akira Sone** and Naoki Yamamoto, “Quantum Inception Score as an Expressivity Measure of the Quantum Generative Models”, [APS March Meeting](#), Minneapolis, MI, USA, March 2024
5. Kenji Maeda, Tharon Holdsworth, Sebastian Deffner, and **Akira Sone**, “Irreversibility Measure by Utilizing the Quantum Fluctuation Theorem of One-Time Measurement Scheme”, [APS March Meeting](#), Minneapolis, MI, USA, March 2024
6. Shou-I Tang, Akram Touil, Sebastian Deffner, and **Akira Sone**, “Quantum Speed Limit for the Information Processing of Quantum Thermodynamical Systems”, [APS March Meeting](#), Minneapolis, MI, USA, March 2024
7. Tharon Holdsworth and **Akira Sone**, “Quantum Monge-Kantorovich Problem and the Time Dependent Two Qubit Marginal Problem”, [APS March Meeting](#), Minneapolis, MI, USA, March 2024
8. **Akira Sone**, “Quantum Fluctuation Theorem of the One-Time Measurement Scheme”, [Workshop on non-equilibrium quantum thermodynamics: Stochastic models and experimental platforms](#), Cambridge, MA, USA, June 2023
9. Kenji Maeda, Tharon Holdsworth, Sebastian Deffner, and **Akira Sone**, “Quantum Fluctuation Theorem of the Quantum Work Conditioned on the Initial Energy Measurement”, [APS DAMOP](#), Spokane, WA, USA, June 2023
10. Kenji Maeda, Tharon Holdsworth, Sebastian Deffner, and **Akira Sone**, “Quantum Fluctuation Theorem of the Quantum Work Conditioned on the Initial Energy Measurement” (poster presentation), [Maryland Quantum-Thermodynamics Symposium](#), College Park, MD, USA, March 2023

11. Tharon Holdsworth, Naoki Yamamoto, Prineha Narang, and **Akira Sone**, “Quantum Cross Entropy in Integrated Fluctuation Theorems”, **APS March Meeting**, Las Vegas, NV, USA, March 2023
12. **Akira Sone**, Diogo Soares-Pinto, and Sebastian Deffner, “A Thermal State Conditioned on Pointer Bases and Its Properties”, **APS March Meeting**, Las Vegas, NV, USA, March 2023
13. Bingzhi Zhang, **Akira Sone**, and Quntao Zhuang, “Computational phase transition in Quantum Approximate Optimization Algorithm – the difference between hard and easy”, **APS March Meeting**, Chicago, IL, USA, March 2022
14. **Akira Sone** and Sebastian Deffner, “Jarzynski equality for conditional stochastic work” (Poster presentation), **DPG (Deutsche Physikalische Gesellschaft) Spring Meeting**, virtual, March 2021
15. **Akira Sone** and Sebastian Deffner, “Geometry of thermal state – thermodynamics of quantum and classical coherence”, **APS March Meeting**, virtual, March 2021
16. Jacob Beckey, **Akira Sone**, Marco Cerezo, and Patrick Coles, “Variational Quantum Algorithms for Quantum Sensor Evaluation”, **APS March Meeting**, virtual, March 2021
17. Marco Cerezo, **Akira Sone**, Kunal Sharma, Tyler Volkoff, Lukasz Cincio, and Patrick Coles, “Barren Plateaus in Quantum Neural Networks”, **APS March Meeting**, virtual, March 2021
18. Samson Wang, Enrico Fontana, Marco Cerezo, Kunal Sharma, **Akira Sone**, Lukasz Cincio, and Patrick Coles, “Noise-Induced Barren Plateaus in Variational Quantum Algorithms”, **APS March Meeting**, virtual, March 2021
19. **Akira Sone**, Jacob L. Beckey, Marco Cerezo, and Patrick Coles, “Quantum Fisher Information estimation via hybrid quantum-classical computation” (Poster presentation), **Quantum Techniques in Machine Learning**, Cambridge, MA, USA, November 2020
20. Marco Cerezo, **Akira Sone**, Tyler Volkoff, Kunal Sharma, Lukasz Cincio, and Patrick Coles, “Trainability of Quantum Neural Networks”, **Quantum Techniques in Machine Learning**, Cambridge, MA, USA, November 2020
21. **Akira Sone**, Yi-Xiang Liu, and Paola Cappellaro, “Nonequilibrium work relations of open quantum systems in one-time measurement scheme”, **APS March Meeting**, Denver, CO, USA, March 2020
22. Marco Cerezo, **Akira Sone**, Lukasz Cincio, and Patrick J. Coles, “Barren Plateau Issues for Variational Quantum-Classical Algorithms”, **APS March Meeting**, Denver, CO, USA, March 2020
23. **Akira Sone**, Quntao Zhuang, Changhao Li, Yi-Xiang Liu, and Paola Cappellaro, “Role of nonclassical correlations in quantum parameter estimation assisted by a local measurement scheme in thermal equilibrium”, **APS March Meeting**, Boston, MA, USA, March 2019
24. Xiaoyang Huang, Roberto Gauna, **Akira Sone**, and Paola Cappellaro, “Practical algorithm for determining Hamiltonian identifiability” (Poster presentation), **APS March Meeting**, Boston, MA, USA, March 2019

25. **Akira Sone**, Quntao Zhuang, and Paola Cappellaro, “Nonclassical correlations in local quantum thermometry” (Poster presentation), [AQIS’18](#), Nagoya, Japan, September 2018
26. **Akira Sone** and Paola Cappellaro, “Quantum-assisted dimension estimation of an interacting qubit system”, [APS DAMOP](#), Fort Lauderdale, FL, USA, June 2018
27. **Akira Sone** and Paola Cappellaro, “Hamiltonian identifiability assisted via single-probe measurement”, [APS DAMOP](#), Sacramento, CA, USA, June 2017

News

1. Advancing the field of quantum thermodynamics, [MIT NSE News](#)
2. Solving ‘barren plateaus’ is the key to quantum machine learning, [Phys.org News](#)

Scholarships

1. **Funai Overseas Scholarship** (for Ph. D study), September, 2013 ~ August, 2015
2. **Postdoctoral Scholarship of Funai Foundation for Information Technology**, \$10,000/year, April, 2019 ~ March, 2020
3. **Postdoctoral Scholarship of Funai Foundation for Information Technology**, \$10,000/year, April, 2020 ~ March, 2021

Certificate

Kaufman Teaching Certificate, May 2019 (Awarded from MIT)

Teaching honors/awards

- (1) **Thomas G. Stockham Jr. Fellowship**, September 2018 ~ May 2019 (Awarded by School of Engineering, MIT)
- (2) **Outstanding Teaching Assistant Award** for exceptional contributions as a teaching assistant in Nuclear Science and Engineering, May 2016 (Awarded by Department of Nuclear Science and Engineering, MIT)

Teaching experience

Year	Course title	Level/School
Fall 2015	Applied Nuclear Physics	Graduate, MIT
Spring 2018	Introduction to Applied Nuclear Physics	Undergraduate, MIT
Spring 2019	Atomic and Optical Physics II	Graduate, MIT
Spring 2019	Quantum Theory of Radiation Interaction	Graduate, MIT
Fall 2022	Quantum Information I	Undergraduate, UMass Boston
Spring 2023	Quantum Information III	Undergraduate, UMass Boston
Fall 2023	Quantum Control Theory	Graduate, UMass Boston
Spring 2024	Thermodynamics	Undergraduate, UMass Boston
Fall 2024	Introduction to Contemporary Physics (Special Relativity and Quantum Mechanics)	Undergraduate, UMass Boston

(* I am also a guest lecturer of graduate-level course 22.51 “Quantum Technology and Devices” at MIT)

Students

Yifan Qian (Computational Science, University of Massachusetts Boston, Ph.D.)

Shou-I Tang (Physics, UMass Boston, master)

Kenji Maeda (Physics, UMass Boston, undergraduate, Goldwater scholar)

Tharon Holdsworth (Physics, UMass Boston, master); currently Texas A&M Ph. D. student, physics

Jacob L. Beckey (Physics, University of Colorado, Boulder, Summer 2020, at LANL)

Samson Wang (Physics, Imperial College of London, UK, Summer 2020, at LANL)

Enrico Fontana (Computer Science, University of Strathclyde, UK, Summer 2020, at LANL)

Roberto Gauna (EECS, MIT, Fall 2018 ~ Spring 2019, at MIT)

Xiaoyang Huang (Physics, MIT and Xi'an Jiaotong University, China, Fall 2018 ~ Spring 2019, at MIT, currently University of Colorado, Boulder, Ph.D. candidate)

Service

Referee for [Physical Review X](#), [PRX Quantum](#), [Physical Review Letters](#), [Physical Review E](#), [Physical Review A](#), [Physical Review Research](#), [New Journal of Physics](#), [Communications Physics](#), [Quantum](#), [Quantum Science and Technology](#), [Entropy](#), [IEEE Transactions on Evolutionary Computation](#), [IEEE Control Systems Letter](#), [Europhysics Letters](#).

Education service

Judge for iQuHACK (2023) at Massachusetts Institute of Technology, January 2023

Referee Awards

IOP trusted reviewer for peer review excellence, IOP Publishing, September 2020

Techniques

MATLAB, Mathematica, C++, Python

Languages

Japanese (native), Mandarin Chinese (fluent), English (fluent)