Christopher R Monroe

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Education

1992 Ph.D., Physics, University of Colorado, Boulder, CO (Advisor: Carl Wieman)
1987 S.B., Physics, Massachusetts Institute of Technology, Cambridge MA (Advisor: Michael Feld)
1983 Detroit Catholic Central High School, Redford MI

Positions

2021–	**Duke Quantum Center**	**Founding Director**
2021–	**Duke University, Durham NC**	**Gilhuly Family Presidential Distinguished Professor**
2021–	**Duke University, Durham NC**	**Professor of Physics and Electrical and Computer Eng.**
2021–	**Univ. of Maryland, College Park**	**College Park Professor of Physics**
2018–2019	IonQ, Inc., College Park	Chief Executive Officer
2018–2020	Univ. of Maryland, College Park	Professor, Electrical and Computer Engineering Dept.
2016–	**IonQ, Inc., College Park**	**Chief Scientist and Co-Founder**
2015–2020	Univ. of Maryland, College Park	Distinguished University Professor
2014–	**Univ. of Maryland, College Park**	**Fellow, Center for Quantum Info. & Comp. Sci. (QuICS)**
2007–	**Univ. of Maryland, College Park**	**Fellow, Joint Quantum Institute (JQI)**
2007–2020	Univ. of Maryland, College Park	Bice Zorn Professor of Physics
2006–2007	Univ. of Michigan, Ann Arbor	Director, FOCUS (NSF Frontier Center on Ultrafast Science)
2006–2007	Univ. of Michigan, Ann Arbor	Professor, Electrical Engineering and Computer Science Dept.
2003–2007	Univ. of Michigan, Ann Arbor	Professor, Physics Dept.
2000–2003	Univ. of Michigan, Ann Arbor	Associate Professor, Physics Dept.
1995–2000	Univ. of Colorado, Boulder	Adjunct Lecturer, Physics Dept.
1994–2000	National Inst. of Stand. Tech., Boulder	Staff Physicist and Project Leader
1992–1994	National Inst. of Stand. Tech., Boulder	NRC Postdoctoral Researcher (Mentor: David Wineland)

Fellowships and Awards

Fellow, Optical Society of America (2020)
Willis E. Lamb Award for Laser Science and Quantum Optics (2019)
Member, National Academy of Sciences (2016)
American Physical Society Arthur Schawlow Prize for Laser Science (2015)
University of Maryland College of Science Distinguished Faculty Award (2014)
Fellow, American Association for the Advancement of Science (2012)
Scientific American "50" Research Award (2006)
University of Michigan Faculty Distinguished Research Award (2005-2006)
Fellow, American Physical Society (2005)
Fellow, UK Institute of Physics (2002)
Distinguished Traveling Lecturer, American Physical Society Division of Laser Science (2002–)
American Physical Society I.I. Rabi Award (2001)
International Quantum Communication Award, Tamagawa University, Japan (2000)
US Presidential Early Career Award for Scientists and Engineers (1997)
National Research Council Postdoctoral Fellowship (1992-1994)
University of Colorado Feldkamp Award for Graduate Research (1990)

Service

Committees

US Presidential National Quantum Initiative Advisory Committee (NQIAC) (2020–2022)
American Physical Society Div. AMO Physics (DAMOP): **Chair** (2010), Chair-Elect (2009), Vice-Chair (2008).
American Physical Society Topical Group on Quantum Information: Executive Committee (2008-2010).

American Physical Society Committee on Meetings: **Chair** (2005), Member (2003-2004).
National Academy of Sciences Committee on AMO science (CAMOS): **Chair** (2012-2015), Member (2009-2011).
National Academy of Sciences Committee on AMO science (AMO2010 decadal report, 2005-2006).

Boards
Max Planck Institute for Quantum Optics, Scientific Advisory Board (2018–)
CalTech Institute for Quantum Information and Matter, Advisory Board (2018–)
Center for Quantum Technology, National University of Singapore: Technical Advisory Board (2018–).
National Academies of Sciences Intelligence Science and Technology Experts Group (ISTEG) (2015–)
DoD Advisory Board for Quantum Sciences and Engineering at ARL, AFRL, and NRL (2015–).
JILA and Univ. of Colorado NSF Physics Frontier Center External Advisory Board (2014–).
Center for Quantum Information, Tsinghua University, Beijing, China: International Advisory Board (2012–).
Institute for Quantum Computing, University of Waterloo, Canada: Scientific Advisory Committee (2010–).
Networked Quantum Information Technology Hub, Oxford University, UK: Scientific Advisory Committee (2013–).
Physics and Engineering Physics Department, Stevens Institute of Technology: External Advisory Board (2009–).

Organization and Outreach
Founding General Chair, Quantum 2.0 Optical Society of America conference (2020, 2022).
US National Quantum Initiative Founding Stakeholder; testified to US Congress in Oct 2017, May 2018, and May 2021
Founding Organizer, Biennial Michigan Summer School on Quantum Physics (2008–2014).
Chair, Gordon Research Conference on Atomic Physics (2007).
Director, *Enrico Fermi International School of Physics* on "Quantum Information Science" (2001).

Editorial
Nature: Quantum Information: Editorial Board (2015–).
Journal of Optics B: Editorial Board (2003-2007), Advisory Board (2008-2012).
Journal of Quantum Information (Rinton Press): Editorial Advisory Board (2000–).

Research Interests

I am an experimentalist in the areas of quantum information systems, quantum computing, quantum communication, atomic, molecular, and optical physics, and quantum optics. My research interests include:

Quantum Information Systems. Quantum information science exploits the properties of quantum superposition and quantum entanglement to store and process information in ways that are not possible classically. I have a longstanding interest in the fabrication of quantum processing systems using atoms and photons, natural carriers of quantum information. This includes the design and realization of entangling quantum logic gates between atoms, the quantum networking of remotely-located atoms with photons, and the scaling to much larger numbers of atomic quantum bits with advanced microfabricated atom trap array and photonic structures.

Cold Atomic Physics. Atoms can be localized to nanometer precision with electromagnetic fields and laser cooling techniques. My interest in this area involves the use of laser radiation to prepare, characterize, and exploit nearly-pure quantum states of internal (electronic) and external (motional) degrees of freedom of cold atoms and ions in order to generate controllable interactions and quantum entanglement for studies of quantum many-body systems.

The Interface between Atomic and Condensed Matter Physics. My group has led the development of atomic quantum simulators that can emulate intractable Hamiltonians that are found in contexts such as quantum magnetism and strongly-correlated condensed matter. We have also developed the use of microfabricated semiconductor structures for confining individual atomic ions in free space, while also characterizing the electrical noise processes of semiconductor and other electrode materials using single atoms as sensitive probes. More generally, I am interested in juxtaposing atomic systems with mesoscopic condensed-matter systems, including photonic couplings between atomic ions and quantum dots and electro-mechanical couplings between mesoscopic oscillators and atoms.

Ultrafast Control of Cold Atoms. I am actively pursuing the use of ultrafast ($\sim 10^{-12}$ s) optical techniques for the manipulation and control of cold atomic systems and the generation of multi-atom entangled quantum states. Ultrafast control eliminates sensitivity to slower decoherence processes, and represents a new regime of ultracold atomic physics.

Foundations of Quantum Mechanics. I have a longstanding interest in foundational aspects of quantum mechanics, from quantum measurement, quantum decoherence, and alternative interpretations of quantum mechanics, to the general phenomenon of quantum entanglement and various forms of Bell's Inequalities. I am interested in quantum metrology and the border between quantum and classical physics as system complexity grows. I enjoy conveying quantum tenets to younger students and the public, with heavy reliance on analogies from the visual and musical arts.

Grants ($5M external funding in AY2021-2022)

- 2020-2025, DOE Office of Science ($12,500,000 to Duke), "Quantum Systems Accelerator," co-PI with 12 others
- 2019-2024, MURI/AFOSR ($1,250,000 to UMD), "Dissipative Control of Quantum Systems," co-PI with 6 others
- 2018-2020, DOE Basic Energy Sciences, "Developing and Running Quantum Algorithms for Chemistry and Materials" ($1,260,000 to UMD); co-PI with 7 others
- 2018-2020, DOE High Energy Physics, "The Geometry and Flow of Quantum Information: From Quantum Technology to Quantum Gravity" ($452,000 to UMD); co-PI with 11 others.
- 2018-2020, DARPA DRINQS Program, "Driven Quantum Matter for Memory and Metrology (DQM^3)," ($987,500 to UMD); co-PI with 7 others
- 2018-2023, NSF/PFCQC ($3,410,000 to UMD) "STAQ: Software-Tailored Arch. for Quantum co-design," co-PI with 7 others.
- 2018-2023, MURI/AFOSR ($1,250,000 to UMD), "Scalable Certification of Quantum Devices and Networks"
- 2016-2022, MURI/ARO ($1,250,000 to UMD), "Modular Quantum Circuits"
- 2016-2023, IARPA/ARO LogiQ Program ($10,300,000 to UMD) "Error-Corrected Univ. Ion Trap Quant. Comp., co-PI with 8 others
- 2015-2020, ARL – ($1,000,000) "Quantum Networks," co-PI with 12 others
- 2014-2017, Intelligence Community Postdoctoral Fellowship – National Geospatial Agency ($350,000).
- 2015-2017, LPS – ($580,000) "Ultrafast Quantum Gates with Trapped Ions," PI
- 2014-2018, ARO – ($800,000) "Quantum Dynamics with Trapped Ion Spin Chains," PI.
- 2014-2016, Lockheed, Inc – ($1,800,000) "LM/UMD Quantum Engineering Center," PI and Director.
- 2014-2019, MURI/AFOSR ($1,250,000 to UMD), "Wiring Quantum Networks with Mechanical Transducers"
- 2014-2019, MURI/AFOSR ($1,750,000 to UMD), "Optimal Measurements for Scalable Quantum Technologies"
- 2014-2019, NSF Physics Frontier Center ($500,000) "JQI: Processing Quantum Coherence," co-PI.
- 2012-2015, DARPA Defense Science Office ($670,000 to UMD), "Scalable Platform for Agile extended-Reach Quantum Communication (SPARQC)," co-PI with 8 others at 6 institutions.
- 2011-2013, AFOSR/STTR ($270,000 to UMD) "Monolithic quartz ion trap chip" with Translume, Inc.
- 2010-2015, IARPA/ARO MQCO Program ($3,450,000 to UMD) "Modular Universal Scalable Ion Trap Quantum Computer (MUSIQC)," co-PI with 6 others at 6 institutions.
- 2010-2012, European Commission AQUTE Network ($280,000) "Quantum Technology with Atoms"
- 2010-2011, DURIP/ARO ($138,000) "Modelocked Laser for Ultrafast Quantum Gates."
- 2009-2012, NSF Physics at the Information Frontier ($450,000) "Photonic Networking of Trapped Ion Qubits."
- 2009-2014, MURI/ARO ($1,125,000 to UMD), "Quantum-Optical Circuits of Hybrid Quantum Memories," Lead PI, with 11 co-PIs.
- 2008-2011, Intelligence Community Postdoctoral Fellowship – National Geospatial Agency ($350,000).
- 2008-2013, NSF Physics Frontier Center ($500,000) "JQI: Processing Quantum Coherence," co-PI.
- 2008-2009, IARPA/ARO ($500,000), "Trapped Ion Quantum Networks," PI.
- 2007-2013, DARPA OLE Program ($1,575,000 to UMD), "Quantum Simulation of Magnetic Spin Phases with Atoms and Ions in Optical Lattices," Lead PI, with 13 co-PIs.
- 2006-2009, NSF Physics at the Information Frontier ($450,000) "Photonic Networking of Trapped Ion Qubits."
- 2005-2006, DURIP – Army Research Office ($115,000) "Ultrafast Photoionization Loading of Ion Traps."
- 2005-2006, DARPA and MEMS Exchange ($205,000), "MEMS fabrication of silicon ion traps."
- 2004-2008, Army Research Office and DTO ($2,200,000) "Trapped Ion Quantum Information Processing"
- 2003-2004, NIST SBIR and Aerophysics, Inc. ($120,000) "Microscale Mass Spetrometer Arrays," co-PI with PIs L. B. King (Michigan Tech) and S. Satyuk (Aerophysics, Inc.)
- 2003-2006, NSF Information Tech. Research ($2,300,000) "Trapped Ion Cavity-QED," co-PI
- 2001-2008, NSF Physics Frontier Centers ($750,000) "FOCUS: Frontiers of Optical Coherent and Ultrafast Science," PI and Director (2006-2007); co-PI with 26 others at Univ. Michigan and Univ. Texas (2001-2005).
- 2001-2004, ARDA/ARO ($1,600,000) "Trapped Ion Quantum Computing."
- 2001-2002, ARO/DURIP ($120,000) "High-fidelity Optical Processes in Trapped Atoms."
- 2001-2004, NSF Information Technology Research ($500,000) "Entanglement of Atomic Cadmium Ions."
- 1995-2000, NSA ($2,500,000), "Ion Trap Quantum Computing," co-PI with D. Wineland (NIST).

Patents and Intellectual Property

- 12 awarded patents
- 28 pieces of intellectual property pending patent awards

Research Journal Preprints under Review

1. "*Continuous Symmetry Breaking in a Trapped-Ion Spin Chain*," L. Feng, O. Katz, C. Haack, M. Maghrebi, A. V. Gorshkov, Z. Gong, M. Cetina, and C. Monroe, arXiv:2211.01275 (2022).
2. "*Experimental Implementation of an Efficient Test of Quantumness*," L. Lewis, D. Zhu, A. Gheorghiu, C. Noel, O. Katz, B. Harraz, Q. Wang, A. Risinger, L. Feng, D. Biswas, L. Egan, T. Vidick, M. Cetina, and C. Monroe, arXiv:2209.14316 (2022).
3. "*Demonstration of three- and four-body interactions between trapped-ion spins*," Or Katz, Lei Feng, Andrew Risinger, Christopher Monroe, Marko Cetina, arXiv:2209.05691 (2022).
4. "*Engineering dynamically decoupled quantum simulations with trapped ions*," W. Morong, K. S. Collins, A. De, E. Stavropoulos, T. You, and C. Monroe, arXiv:2209.05509 (2022).
5. "*Programmable* Quantum Simulations of Bosonic Systems with Trapped Ions," O. Katz and C. Monroe, arXiv:2207.13653 (2022).
6. "*Quantum Simulation for High Energy Physics*," C. W. Bauer, et al., arXiv:2204.03381 (2022).
7. "*Programmable Quantum Simulations of Bosonic Systems with Trapped Ions*," O. Katz and C. Monroe, arXiv:2207.13653 (2022).
8. "*Programmable N-body interactions with trapped ions*," O. Katz, M. Cetina, and C. Monroe, arXiv:2207.10550 (2022).
9. "*Interactive Protocols for Classically-Verifiable Quantum Advantage*," D. Zhu, G. D. Kahanamoku-Meyer, L. Lewis, C. Noel, O. Katz, B. Harraz, Q. Wang, A. Risinger, L. Feng, D. Biswas, L. Egan, A. Gheorghiu, Y. Nam, T. Vidick, U. Vazirani, N. Y. Yao, M. Cetina, and C. Monroe, arXiv:2112.05156 (2022).
10. "*Digital quantum simulation of NMR experiments*," K. Seetharam, D. Biswas, C. Noel, A. Risinger, D. Zhu, O. Katz, S. Chattopadhyay, M.Cetina, C. Monroe, E. Demler, and Dries Sels, arXiv:2109.13298 (2021).
11. "*Cross-Platform Comparison of Arbitrary Quantum Computations*," D. Zhu, Z.-P. Cian, C. Noel, A. Risinger, D. Biswas, L. Egan, Y. Zhu, A. M. Green, A. Maksymov, Y. Nam, M. Cetina, N. M. Linke, M. Hafezi, and C. Monroe, arXiv:2107.11387 (2021).

Research Journal Publications (>55,000 citations, h=97)

1. "*Observation of measurement-induced quantum phases in a trapped-ion quantum computer*," C. Noel, P. Niroula, D. Zhu, A. Risinger, L. Egan, D. Biswas, M. Cetina, A. V. Gorshkov, M. J. Gullans, D. A. Huse, C. Monroe, **Nature Physics 18**, 760 (2022).
2. "*N-body interactions between trapped ion qubits via spin-dependent squeezing*," O. Katz, M. Cetina, and C. Monroe, ***Phys. Rev. Lett.* 129**, 063603 (2022).
3. "*Many-body quantum teleportation via operator spreading in the traversable wormhole protocol*," T. Schuster, B. Kobrin, P. Gao, I. Cong, E. T. Khabiboulline, N. M. Linke, M. D. Lukin, C. Monroe, B. Yoshida, and N. Y. Yao, ***Phys. Rev. X Quantum* 12**, 031013 (2022).
4. "Observation of measurement-induced quantum phases in a trapped-ion quantum computer," C. Noel, P. Niroula, D. Zhu, A. Risinger, L. Egan, D. Biswas, M. Cetina, A. V. Gorshkov, M. J. Gullans, D. A. Huse, C. Monroe, ***Nature Physics* 18**, 760 (2022).
5. "*Control of Transverse Motion for Quantum Gates on Individually Addressed Atomic Qubits*," M. Cetina, L.N. Egan, C. Noel, M.L. Goldman, D. Biswas, A.R. Risinger, D. Zhu, and C. Monroe, ***Phys. Rev. X Quantum* 3**, 010334 (2022).
6. "*Comparison of Cloud-Based Ion Trap and Superconducting Quantum Computer Architectures*," S. Blinov, B. Wu, and C. Monroe, ***AVS Quantum Sci.* 3**, 033801 (2021)
7. "*Observation of Stark many-body localization without disorder*," W. Morong, F. Liu, P. Becker, K. S. Collins, L. Feng, A. Kyprianidis, G. Pagano, T. You, A. V. Gorshkov, and C. Monroe, ***Nature* 599**, 393 (2021).
8. "*Observation of a prethermal discrete time crystal*," A. Kyprianidis, F. Machado, W. Morong, P. Becker, K. S. Collins, D. V. Else, L. Feng, P. W. Hess, C. Nayak, G. Pagano, N. Y. Yao, and C. Monroe, to appear in ***Science* 372**, 1192 (2021).
9. "*Optimizing Stabilizer Parities for Improved Logical Qubit Memories*," Dripto M. Debroy, Laird Egan, Crystal Noel, Andrew Risinger, Daiwei Zhu, Debopriyo Biswas, Marko Cetina, Chris Monroe, and Kenneth R. Brown, ***Phys. Rev. Lett.* 127**, 240501 (2021).
10. "*Fault-Tolerant Operation of a Quantum Error-Correction Code*," L. N. Egan, D. M. Debroy, C. Noel, A. Risinger, D. Zhu, D. Biswas, M. Newman, M. Li, K. R. Brown, M. Cetina, and C. Monroe, ***Nature* 598**, 281 (2021).
11. "*Probing many-body localization on a noisy quantum computer*," D. Zhu, S. Johri, N. H. Nguyen, C. Huerta Alderete, K. A. Landsman, N. M. Linke, C. Monroe and A. Y. Matsuura, ***Phys. Rev. A* 103**, 032606 (2021).

12. "*Domain Wall Confinement and Dynamics in a Quantum Simulator*," L. Tan, P. Becker, F. Liu, G. Pagano, K. S. Collins, A. De, L. Feng, H. B. Kaplan, A. Kyprianidis, R. Lundgren, W. Morong, S. Whitsitt, A. V. Gorshkov, C. Monroe, ***Nature Physics*** **17**, 742 (2021).
13. "*The Character of Motional Modes for Entanglement and Sympathetic Cooling of Mixed-Species Trapped Ion Chains*," K. Sosnova, A. Carter, and C. Monroe, ***Phys. Rev. A*** 103, 012610 (2021).
14. "*Efficient ground-state cooling of large trapped-ion chains with an EIT tripod scheme*," L. Feng, W. L. Tan, A. De, A. Menon, A. Chu, G. Pagano, and C. Monroe, ***Phys. Rev. Lett.*** **125**, 053001 (2020).
15. "*Resource-Optimized Fermionic Local-Hamiltonian Simulation on Quantum Computer for Quantum Chemistry*," Q. Wang, M. Li, C. Monroe, Y. Nam, ***Quantum*** **5**, 509 (2021).
16. "*Universal one-dimensional discrete-time quantum walks and their implementation on near term quantum hardware*," S. Singh, C. H. Alderete, R. Balu, C. Monroe, N. M. Linke, and C. M. Chandrashekar, ***Phys. Rev. A*** **104**, 062401 (2021)
17. "*Many-Body Dephasing in a Trapped-Ion Quantum Simulator*," H. B. Kaplan, L. Guo, W. L. Tan, A. De, F. Marquardt, G. Pagano, and C. Monroe, ***Phys. Rev. Lett.*** **125**, 120605 (2020).
18. "*Noise reduction using past causal cones in variational quantum algorithms*," Omar Shehab, Isaac H. Kim, Nhung H. Nguyen, Kevin Landsman, Cinthia H. Alderete, Daiwei Zhu, C. Monroe, Norbert M. Linke, arXiv 1906.00476 (2019).
19. "*Quantum walks and Dirac cellular automata on a programmable trapped-ion quantum computer*," C. H. Alderete, S. Singh, N. Nguyen, D. Zhu, R. Balu, C. Monroe, C. M. Chandrashekar, and N. M. Linke, ***Nature Communications*** **11**, 3720 (2020).
20. "*Quantum Approximate Optimization with a Trapped-Ion Quantum Simulator*," G. Pagano, A. Bapat, P. Becker, K. S. Collins, A. De, P. W. Hess, H. B. Kaplan, A. Kyprianidis, W. L. Tan, C. Baldwin, L. T. Brady, A. Deshpande, F. Liu, S. Jordan, A. V. Gorshkov, C. Monroe, ***Proc. Nat. Acad. Sci.*** **117**, 25396 (2020).
21. "*Variational Generation of Thermofield Double States and Critical Ground States with a Quantum Computer*," D. Zhu, S. Johri, N. M. Linke, K. A. Landsman, N. H. Nguyen, C. H. Alderete, A. Y. Matsuura, T. H. Hsieh, C. Monroe, ***Proc. Nat. Acad. Sci.*** **117**, 25402 (2020).
22. "*Towards analog quantum simulations of lattice gauge theories with trapped ions*," Z. Davoudi, M., C. Monroe, G. Pagano, A. Seif, and A. Shaw, ***Phys. Rev. Research*** **2**, 023015 (2020).
23. "*Two-qubit entangling gates within arbitrarily long chains of trapped ions*," K. A. Landsman, Y. Wu, P. H. Leung, D. Zhu, N. M. Linke, K. R. Brown, L.-M. Duan, and C. Monroe, ***Phys. Rev. A*** **100**, 022332 (2019).
24. "*Toward convergence of effective field theory simulations on digital quantum computers*," O. Shehab, K. A. Landsman, Y. Nam, D. Zhu, N. M. Linke, M. J. Keesan, R. C. Pooser, and C. Monroe, ***Phys. Rev. A*** **100**, 062319 (2019).
25. "*Benchmarking an 11-qubit quantum computer*," K. Wright, et al., ***Nature Communications*** **10**, 5464 (2019).
26. "*Ground-state energy estimation of the water molecule on a trapped ion quantum computer*," Y. Nam, et al., ***Nature Quantum Information*** **6**, 33 (2020)..
27. "*Heisenberg-Scaling Measurement Protocol for Analytic Functions with Quantum Sensor Networks*," K. Qian, Z. Eldredge, W. Ge, G. Pagano, C. Monroe, J. V. Porto, and A. V. Gorshkov, ***Phys. Rev. A*** **100**, 042304 (2019).
28. "*Parallel Entangling Operations on a Universal Ion Trap Quantum Computer*," C. Figgatt, A. Ostrander, N. M. Linke, K. A Landsman, D. Zhu, D. Maslov, C. Monroe, ***Nature*** **567**, 61 (2019)
29. "*Verified Quantum Information Scrambling*," K. A Landsman, C. Figgatt, T. Schuster, N. M. Linke, B. Yoshida, N. Y. Yao, C. Monroe, ***Nature*** **567**, 61 (2019); [News and Views].
30. "*Confined Quasiparticle Dynamics in Long-Range Interacting Quantum Spin Chains*," F. Liu, R. Lundgren, P. Titum, G. Pagano, J. Zhang, C. Monroe, and A. V. Gorshkov, ***Phys. Rev. Lett.*** **122**, 150601 (2019).
31. "*Training of Quantum Circuits on a Hybrid Quantum Computer*," D. Zhu, N. M. Linke, M. Benedetti, K. A. Landsman, N. H. Nguyen, C. H. Alderete, A. Perdomo-Ortiz, N. Korda, A. Garfoot, C. Brecque, L. Egan, O. Perdomo, and C. Monroe, ***Science Advances*** **5**, eaaw9918 (2019).
32. "*High Purity Single Photons Entangled with an Atomic Memory*," C. Crocker, M. Lichtman, K. Sosnova, A. Carter, S. Scarano, and C. Monroe, ***Optics Express*** **27**, 28143 (2019).
33. "*Quantum repeaters based on two species trapped ions*," Santra, S. Muralidharan, M. Lichtman, L. Jiang, C. Monroe, and V. S. Malinovsky, ***New J. Phys.*** **21** 073002 (2019).
34. "*Cryogenic Trapped-Ion System for Large Scale Quantum Simulation*," G. Pagano, P.W. Hess, H. B. Kaplan, W. L. Tan, P. Richerme, P. Becker, A. Kyprianidis, J. Zhang, E. Birckelbaw, M. R. Hernandez, Y. Wu, C. Monroe, ***Quantum Sci. Tech.*** **4**, 014004 (2018).
35. "*Measuring the Renyi entropy of a two-site Fermi-Hubbard model on a trapped ion quantum computer*," N. M. Linke, S. Johri, C. Figgatt, K. A. Landsman, A. Y. Matsuura, and C. Monroe, ***Phys. Rev. A*** **98**, 052334 (2018).
36. "*Machine Learning Assisted Readout of Trapped Ion Qubits*," A. Seif, K. A. Landsman, N. M. Linke, C. Figgatt, C. Monroe, and M. Hafezi, ***J. Phys. B: At. Mol. Opt. Phys.*** **51** 174006 (2018).
37. "*Demonstration of a Bayesian Quantum Game on an Ion Trap Quantum Computer*," N. Solmeyer, N. M. Linke, C. Figgatt, K. A. Landsman, R. Balu, G. Siopsis, C. Monroe, ***Quantum Sci. Tech.*** **3**, 045002 (2018).

38. "*Observation of Hopping and Blockade of Bosons in a Trapped Ion Spin Chain*," S. Debnath, N. M. Linke, S.-T. Wang, C. Figgatt, K. A. Landsman, L.-M. Duan, and C. Monroe, ***Phys. Rev. Lett.*** **120**, 073001 (2018).
39. "*Robust two-qubit gates in a linear ion crystal using a frequency-modulated driving force*," P.-H. Leung, K. A. Landsman, C. Figgatt, N. M. Linke, C. Monroe, and K. R. Brown, ***Phys. Rev. Lett.*** **120**, 020501 (2018).
40. "*Demonstration of two-atom entanglement with ultrafast optical pulses*," J. D. Wong-Campos, S. A. Moses, K. G. Johnson, and C. Monroe, ***Phys. Rev. Lett.*** **119**, 230501 (2017).
41. "*Observation of a Many-Body Dynamical Phase Transition in a 53-Qubit Quantum Simulator*," J. Zhang, G. Pagano, P. W. Hess, A. Kyprianidis, P. Becker, H. B. Kaplan, A. V. Gorshkov, Z.-X. Gong, and C. Monroe, ***Nature*** **551**, 601 (2017).
42. "*Complete 3-Qubit Grover Search on a Programmable Quantum Computer*," C. Figgatt, D. Maslov, K. A. Landsman, N. M. Linke, S. Debnath, C. Monroe, ***Nature Comm.*** **8**, 1918 (2017).
43. "*Fault-Tolerant Quantum Error Detection*," N. M. Linke, M. Gutierrez, K. A. Landsman, C. Figgatt, S. Debnath, K. R. Brown, C. Monroe, ***Science Advances*** **3**, e1701074 (2017).
44. "*Multi-Species Trapped Ion Node for Quantum Networking*," I. V. Inlek, C. Crocker, M. Lichtman, K. Sosnova, and C. Monroe, ***Phys. Rev. Lett.*** **118**, 250502, (2017).
45. "*Ultrafast Creation of Large Schrödinger Cat States of an Atom*," K. G. Johnson, J. D. Wong-Campos, B. Neyenhuis, J. Mizrahi, C. Monroe, ***Nature Comm.*** **8**, 697 (2017).
46. "*Experimental Comparison of Two Quantum Computing Architectures*," N. M. Linke, D. Maslov, M. Roetteler, S. Debnath, C. Figgatt, K. A. Landsman, K. Wright, C. Monroe, ***Proc. Nat'l Acad. Sci.*** **114**, 13 (2017).
47. "*Observation of a Discrete Time Crystal*," J. Zhang, P.W. Hess, A. Kyprianidis, P. Becker, A. Lee, J. Smith, G. Pagano, I.-D. Potirniche, A.C. Potter, A. Vishwanath, N.Y. Yao, C. Monroe, ***Nature*** **543**, 217–220 (2017).
48. "*Observation of Prethermalization in Long-Range Interacting Spin Chains*," B. Neyenhuis, J. Smith, A. Lee, P. Richerme, P. Hess, J. Zhang, Z. Gong, A. Gorshkov, and C. Monroe, ***Science Advances*** **3**, e1700672 (2017).
49. "*Engineering Large Stark Shifts for Control of Individual Clock-State Qubits*," A. C. Lee, J. Smith, P. Richerme, B. Neyenhuis, P. W. Hess, J. Zhang, and C. Monroe, ***Phys. Rev. A*** 94, 042308 (2016).
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