

Ian Mondragon-Shem

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EMPLOYMENT **University of Illinois at Chicago**, Chicago, IL, USA
Assistant Professor 2025 - current

Northwestern University, Evanston, IL, USA
Postdoctoral scholar 2021 - 2025

Argonne National Laboratory, Lemont, IL, USA
Postdoctoral Appointee 2019 - 2021

Yale University, New Haven, CT, USA
Postdoctoral Prize Fellowship 2016 - 2019

RESEARCH INTERESTS
My research program is at the interface of theoretical condensed matter physics and quantum information science, focusing on investigating new forms of quantum matter and the design of quantum hardware for quantum technologies. My interests are organized around three interconnected themes:

Theory and Modeling of Quantum Hardware: Developing realistic models for next-generation quantum devices, particularly superconducting circuits. This includes modeling superconducting circuits, understanding decoherence mechanisms in Josephson junction arrays, and designing Floquet-engineered qubits with novel properties.

Non-Equilibrium and Driven Quantum Matter: Exploring the physics of non-equilibrium quantum many-body systems. This includes the study of quantum many-body scars in Rydberg atom simulators, the design of Floquet topological phases, and investigating non-equilibrium matter for applications like quantum batteries.

Topological and Disordered Quantum Matter: Understanding the interplay of topology, entanglement, and disorder in many-body systems. This includes characterizing topological quantum phase transitions, exploring disorder-induced phenomena, and simulating correlated quantum materials.

EDUCATION **University of Illinois at Urbana-Champaign**, IL, USA
Ph.D., Physics, 2011-2016.
Thesis: Delocalization phenomena in strongly disordered systems.
Advisor: Taylor L. Hughes.

Universidad de Antioquia, Medellin, Colombia
B.S., Physics, 2005-2010.
Senior thesis: Spin-orbit coupled Bose-Einstein condensation.
Advisors: Congjun Wu (UCSD) and Boris Rodriguez (U de A).

University of California, San Diego, CA, USA.
Visiting undergraduate student, 2007-2008.

AWARDS AND RECOGNITIONS

- **Renato Bobone Award** (2016)
Award given by the University of Illinois at Urbana-Champaign to recognize a physics graduate student who has demonstrated academic excellence.
- **Teacher Ranked as Excellent by Their Students. University of Illinois at Urbana-Champaign** (2011, 2012)
Electricity and Magnetism (fall 2011), Quantum Mechanics II (upper level course, spring 2012)
- **Annual award for the most influential paper** (2013)
Recognition by the Chinese Physical Society for the paper *Unconventional Bose-Einstein Condensations from Spin-Orbit Coupling*, Chin. Phys. Lett. 28, 097102 (2011).
- **Otto de Greiff National Contest** (2011)
Award given to best senior thesis in Colombia in the natural sciences.
- **Student Research Award** (2010)
Award given to best senior thesis in the Universidad de Antioquia in the natural sciences.
- **First place in National Physics Test ECAES** (2009)
Recognition for top score in Colombian national undergraduate test which is the equivalent to the Physics GRE.
- **Young researcher fellowship** (2006)
Fellowship granted by the AMO Research Group of the Universidad de Antioquia.
- **Best Student in Program** (2007, 2009)
Awarded for overall highest GPA in the Institute of Physics of the Universidad de Antioquia.
- **Meritorious scholarship** (2005 - 2008)
Awarded for highest GPA of each semester in the Institute of Physics of the Universidad de Antioquia.

LIST OF PUBLICATIONS

In Preparation

- Role of the Top of the Cosine Well in Transmon Ionization, Matthew Capocci, **Ian Mondragon-Shem**, and Jens Koch.
- Systematic Construction of Time-Dependent Hamiltonians for Microwave-Driven Josephson Circuits, Yao Lu, Tianpu Zhao, André Vallières, Kevin C. Smith, Daniel Weiss, Xinyuan You, Yaxing Zhang, Suhas Ganjam, Aniket Maiti, John Garmon, Shantanu Mundhada, Ziwen Huang, **Ian Mondragon**, S. M. Girvin, Jens Koch, Robert J. Schoelkopf.
- **Ian Mondragon-Shem**, Ziwen Huang, Jens Koch. Floquet qubits with flat spectra.
- **Ian Mondragon-Shem**, Maxim G. Vavilov, Ivar Martin. Multiple Scar Towers in Strongly Interacting Rydberg Atoms.

Preprints

- Mingkang Xia, Cristóbal Lledó, Matthew Capocci, Jacob Repicky, Benjamin D'Anjou, **Ian Mondragon-Shem**, Ryan Kaufman, Jens Koch, Alexandre Blais, Michael Hatridge. Exceeding the Parametric Drive Strength Threshold in Nonlinear Circuits. ArXiv:2506.03456 (2025).
- **Ian Mondragon-Shem**, Ivar Martin, A. Alexandradinata, Meng Cheng. Quantized frequency-domain polarization of driven phases of matter. arXiv:1811.10632 (2018).

Peer-Reviewed Publications

- [1] **Ian Mondragon-Shem**, Taylor L Hughes. Robust topological invariants of topological crystalline phases in the presence of impurities. *Phys. Rev. B* 110, 035146 (2024).
- [2] Logan Bishop-Van Horn, Irene P. Zhang, Emily N. Waite, **Ian Mondragon-Shem**, Scott Jensen, Junseok Oh, Tom Lippman, Malcolm Durkin, Taylor L. Hughes, Nadya Mason, Kathryn A. Moler, and Ilya Sochnikov. Local imaging of diamagnetism in proximity-coupled niobium nanoisland arrays on gold thin films. *Phys. Rev. B* 106, 054521 (2022).
- [3] Sai Pavan Chitta, Tianpu Zhao, Ziwen Huang, **Ian Mondragon-Shem**, Jens Koch. Computer-aided quantization and numerical analysis of superconducting circuits. *New J. Phys.* 24, 103020 (2022).
- [4] **Ian Mondragon-Shem**, Maxim G. Vavilov, Ivar Martin. Fate of quantum many-body scars in the presence of disorder. *PRX Quantum* 2 (3), 030349 (2021).
- [5] Tyler Naibert, Hryhoriy Polshyn, Malcolm Durkin, Brian Wolin, Rita Garrido-Menacho, Victor Chua, **Ian Mondragon-Shem**, Taylor Hughes, Nadya Mason, Raffi Budakian. Imaging and controlling vortex dynamics in mesoscopic superconductor–normal-metal–superconductor arrays. *Phys. Rev. B* 103, 224526 (2021).
- [6] M.S. Durkin, **Ian Mondragon-Shem**, Taylor L. Hughes, Nadya Mason. Dissipative vortex dynamics in superconducting arrays. *Phys. Rev. B* 94 (2), 024510 (2016).
- [7] **Ian Mondragon-Shem**, Arijit Pal, Taylor L. Hughes, Chris R. Laumann. Many-body mobility edge due to symmetry-constrained dynamics and strong interactions. *Phys. Rev. B* 92 (6), 064203 (2015).
- [8] **Ian Mondragon-Shem**, Taylor L. Hughes. Entanglement of a 3D generalization of the Kitaev model on the diamond lattice. *Journal of Statistical Mechanics: Theory and Experiment* 2014 (10), P10022 (2014).
- [9] **Ian Mondragon-Shem**, Taylor L. Hughes. Signatures of metal-insulator and topological phase transitions in the entanglement of one-dimensional disordered fermions. *Phys. Rev. B* 90 (10), 104204 (2014).
- [10] **Ian Mondragon-Shem**, J. Song, Taylor L. Hughes, Emil Prodan. Topological Criticality in the Chiral-Symmetric AIII Class at Strong Disorder. *Phys. Rev. Lett.* 113 (4), 046802 (2014).
- [11] **Ian Mondragon-Shem**, M. Khan, Taylor L. Hughes. Characterizing disordered fermion systems using the momentum-space entanglement spectrum. *Phys. Rev. Lett.* 110 (4), 046806 (2013).

- [12] Congjun Wu, **Ian Mondragon-Shem**, X.F. Zhou. Unconventional Bose-Einstein Condensations from Spin-Orbit Coupling. Chinese Physics Letters 28, 097102 (2011).
- [13] **Ian Mondragon-Shem**, B.A. Rodríguez, F.E. López. Efficient calculation of Coulomb matrix elements for bilayers of confined charge carriers with arbitrary spatial separation. Computer Physics Communications 181 (9), 1510-1516 (2010).
- [14] **Ian Mondragon-Shem**, B.A. Rodríguez, F.E. López. Coulomb correlations of a few body system of spatially separated charges. Journal of Physics: Conference Series 193 (1), 012133 (2009).

GRANT WRITING

- **In preparation (PI):** Proposal on the design of superconducting quantum processors to tame the many-body ergodic spread of quantum information outside the computational subspace.
- **Co-PI:** Project “Understanding loss mechanisms in fluxonium devices,” written in conjunction with experimental collaborator from Princeton University. This project received seed funding in the amount \$50,000 from the Co-design Center for Quantum Advantage from the DOE.
- **Contributor:** Contributed to preparation of multi-PI DOE proposal “Probing and Extending Coherence in Analog and Digital Quantum Processors with dual Atomic Species”, led by Professor Mark Saffman (2020).

MENTORING EXPERIENCE

- Currently mentoring a Ph.D. student working on protected superconducting qubits (University of Illinois at Chicago).
- Currently mentoring an undergraduate student from the program of Computer Engineering, researching quantum batteries using non-equilibrium quantum matter (University of Illinois at Chicago).
- Mentor of the Científico Latino Project, Graduate School Mentorship Initiative (2020). This initiative seeks to help students in South America apply to graduate programs in the US.
- Co-advised undergraduate student from the Universidad de Antioquia in research project on topological states of light and matter (2017-2019).
- Mentored undergraduate, master’s and Ph.D. students at Northwestern University.
- Mentored undergraduate students from Computer Science, Computer Engineering and Electrical Engineering at the University of Illinois at Chicago.

TEACHING EXPERIENCE

- **University of Illinois Chicago**
 - Instructor. *ECE 225: Circuit Analysis* (Undergraduate course, 121 students), ECE Department, Fall 2025.
- **Fermilab**
 - Lecture on quantum hardware for quantum computing for high school students, summer 2025.
- **Northwestern University**
 - Substitute lecturer (one time). *Quantum Mechanics* (PHYSICS 412), fall of 2021.

- **University of Illinois at Urbana-Champaign**

- Substitute lecturer (two times). *Condensed Matter Physics* (Physics 460), fall of 2012 and 2015.
- Teaching Assistant (discussion). *Quantum Physics* (Physics 214), second half of spring 2016.
- Teaching Assistant (discussion). *Thermal Physics* (Physics 213), first half of spring 2016.
- Teaching Assistant (discussion). *Electricity and Magnetism* (Physics 212), fall 2011.
- Teaching Assistant (discussion). *Quantum Mechanics II* (Physics 487), spring 2012.

- **Cornell University**

- Teaching Assistant (discussion and laboratory). *Heat and Electromagnetism* (Physics 2213), spring 2011.
- Teaching Assistant (discussion and laboratory). *Wave, Optics and Particles* (Physics 2214), fall 2010.

- **Universidad de Antioquia**

- Teaching Assistant (discussion). *Mechanics* (Physics II), spring 2010.

- **Instituto Jorge Robledo**

- Extracurricular lessons in Physics, Mathematics and Programming at a local high school, 2006.

NEW COURSE DEVELOPMENT

- **Introduction to Quantum Hardware and Quantum Sensing** (Planned for Spring 2026)

Currently designing a new course for the College of Engineering at the University of Illinois Chicago, aimed at undergraduate students. The course will cover leading quantum hardware platforms (superconducting circuits, neutral atoms, trapped ions, NV centers) for computing and sensing.

TALKS AND EVENTS

- **Invited talks**

- Colloquium, Department of Physics, Illinois Institute of Technology, September 2025. *Quantum technologies based on superconducting circuits*.
- Seminar, ECE Department, University of Illinois Chicago, April 2025. *One-mode model description and dephasing of fluxonium superconducting circuits*.
- Seminar, Department of Physics, University of Illinois Chicago, April 2025. *Quantum many-body scars in Rydberg atom simulators*.
- Seminar, University of Wisconsin Madison, March 2025. *Quantum dynamics of noisy and scarred quantum hardware*.
- Seminar, University of Illinois Chicago, January 2024. *Quantum dynamics of noisy and scarred quantum hardware*.
- Seminar, Northwestern University, October 2023. *Non-equilibrium quantum phenomena in circuit QED devices and Rydberg atoms*.
- Talk, Atlantic Quantum, October 2023. *Mitigating the effects of noise in superconducting circuits*.

- Talk, Atom Computing, May 2023. *Non-equilibrium phenomena in circuit QED and Rydberg atom devices.*
- Physics Colloquium, California State University Long Beach, March 2023. *Non-equilibrium and Topological Phenomena in the Era of Quantum Systems by Design.*
- Atomic, Molecular, and Optical Physics Seminar, University of Connecticut, February 2023. *Non-equilibrium phenomena in Rydberg atoms and circuit QED devices.*
- Seminar, Fermilab, February 2022. *Fate of quantum many-body scars in the presence of disorder.*
- 2021 CQE Member and Partner Workshop, April 2021. *Leveraging quantum scars as quantum sensors to detect imperfections in quantum simulators.*
- Talk at Northwestern University, December 2020. *Quantum scar resonances in imperfect quantum simulators.*
- Physics Career Seminar at the University of Illinois at Urbana-Champaign, November 2020. *Experiences from a postdoc at Argonne National Laboratory.*
- Department of Energy Collaboration Meeting at Duke University, November 2019. *Quantum simulations of condensed matter and chemical systems.*
- Quantum Information Science Workshop at Argonne National Laboratory, September 2019. *Robustness of persistent oscillations in kinematically constrained qubit systems.*
- Synthetic Topological Matter Workshop at Max Planck Institute (Dresden), May 2019. *Quantized patterns of frequency-domain polarization.*
- Seminar at Boston University, March 2019. *Quantized patterns of frequency-domain polarization.*
- Seminar at University of California San Diego, January 2019. *Quantized patterns of frequency-domain polarization.*
- Seminar at Indiana University Bloomington, December 2018. *Quantized patterns of frequency-domain polarization.*
- Seminar at Argonne National Laboratory, December 2018. *Quantized patterns of frequency-domain polarization.*
- Seminar at Yale University, December 2015. *Delocalization phenomena in disordered fermions.*
- Inaugural National Conference on Quantum Information and Quantum Computation at the Universidad Nacional, (Bogota, Colombia), February 2010. *Quantum phase transition of light with coupled quantum dots.*

• Contributed talks

- APS March Meeting 2025, *Multiple scar towers in Rydberg quantum simulators*
- APS March Meeting 2024, *Analysis of Josephson junction arrays beyond the single-mode approximation*
- APS March Meeting 2022, *Flattening Floquet spectra of periodically driven quantum systems.*
- APS March Meeting 2021, *Fate of quantum many-body scars in the presence of disorder.*

- APS March Meeting 2019, *Static analogues of driven phases of matter*.
- APS March Meeting 2018, *Non-adiabatic Berry phase description of Floquet topological states*.
- APS March Meeting 2015, *Many-body mobility edge due to symmetry-constrained dynamics and strong interactions*.
- APS March Meeting 2014, *Absence of levitation and annihilation at the topological phase transition of a disordered one-dimensional model in class AIII*.
- APS March Meeting 2013, *Characterizing disordered fermion systems using the momentum-space entanglement spectrum*.
- APS March Meeting 2010, *Unconventional Bose-Einstein condensation with Rashba coupling in optical lattices*.

- **Events (poster)**

- Chicago, October 2022: *Chicago Quantum Summit*.
- New Haven, October 2022: *C2QA All-Hands Meeting*.
- Santa Barbara, August 2018: *Novel approaches to quantum dynamics*.
- Trieste, July 2017: *Fundamental on quantum transport*.
- Boulder, July 2016: *Boulder School 2016: Topological Phases of Quantum Matter*.
- Princeton, July, 2015: *Prospects in Theoretical Physics: New Insights Into Quantum Matter*.
- Minneapolis, May, 2015: *Symmetries and Interactions in Topological Matter*.
- Princeton, April, 2015: *Topological and Strongly Correlated Phases in Cold Atoms*.
- Aspen, March, 2015: *Non-Equilibrium Quantum Matter*.
- Dresden, March, 2015: *Many-body dynamics out of equilibrium*.
- Dresden, March, 2014: *Recent Progress and Perspectives in Scaling, Multifractality, Interactions, and Topological Effects Near Anderson Transitions*.
- Urbana, October, 2014: *Entangled Quantum Matter and Topology*.
- Urbana, October, 2014: *Strongly correlated electron systems at 60 years old*.
- Urbana, November, 2012: *Topology, Entanglement and Strong Correlations in Condensed Matter*.
- Princeton, November, 2010: *Topological Insulators and Superconductors*.
- Kazimierz Dolny, Poland, 2009: *3rd Warsaw School on Statistical Physics*.
- Montpellier, France, 2009: *16th International Conference on Electron Dynamics in Semiconductors, Optoelectronics and Nanostructures*.

REVIEWING ACTIVITIES

• Journal Referee

- Physical Review X (PRX)
- Physical Review Letters (PRL)
- Physical Review B (PRB)
- Physical Review A (PRA)
- Physical Review E (PRE)
- Physical Review Applied
- New Journal of Physics
- Journal of Physics: Condensed Matter
- Annals of Physics

• Proposal and Thesis Reviewer

- Reviewer of research proposals for the *Foundation for the Promotion of Research and Technology* (Central Bank of Colombia).
- Reviewer for masters and doctoral thesis proposals, Department of Physics, Universidad de Antioquia.
- Reviewer for masters thesis, Department of Physics, Universidad de Antioquia.

PROFESSIONAL SERVICE

- Organizer of the Quantum Hardware Workshop, Institute for Mathematical and Statistical Innovation, The University of Chicago, October 2024.
- Tutor for the *Quantum Information Science and Engineering Summer School* hosted by Virginia Tech, August 2022.
- Moderator and Judge at the DOE Illinois Regional Middle School Science Bowl Competition, February 2020.
- Judge for the New Haven Science Fair, May 2019.

PROFESSIONAL DEVELOPMENT

- Faculty Mentoring Workshop, University of Illinois Chicago. Focused on evidence-based strategies (Center for Clinical and Translational Science curriculum) for research mentoring.
- Training on Mental Health First Aid (MHFA). Northwestern University. Spring 2021.

TECHNICAL STRENGTHS

- **Programming languages and tools:** Python, Mathematica, Matlab, C, Git, HPC usage.
- **Languages:** Spanish (native), English (native), French (basic reading knowledge).

PROFESSIONAL Jens Koch

REFERENCES

Professor of Physics
Northwestern University
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Ivar Martin

Group Leader, Sr. Physicist, Materials Science Division
Argonne National Laboratory
E-mail: ivar@anl.gov

Taylor L Hughes

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University of Illinois at Urbana-Champaign
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Emil Prodan

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