

# JACOB L. BECKEY

CURRICULUM VITAE

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## HIGHLIGHTS

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### Research

- Areas of interest: entanglement theory, quantum learning theory, property testing, quantum estimation theory and quantum metrology
- 9 peer-reviewed publications ([Google Scholar Page](#))([Papers on arXiv](#))

### Fellowships

- U.S. DOE Office of Science Graduate Research Award (SCGSR)
- Los Alamos National Lab Quantum Computing Summer School Fellowship
- National Science Foundation Graduate Research Fellowship (NSF GRFP)
- Fulbright - University of Birmingham Postgraduate Award

### Teaching and outreach

- Co-founder and vice president of the [Idealized Science Institute](#), an educational non-profit
- Lecturer for PHYS 3090: Introduction to Quantum Computing at CU Boulder
- Instructor for PHYS 1400: Fundamentals of Scientific Inquiry at CU Boulder

## EDUCATION

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**University of Colorado, Boulder**, Boulder, CO

2019-PRESENT

*M.S. (May 2022), PhD Physics (expected May 2024)*

- Advisor: [Graeme Smith](#)
- Thesis topics: estimation of multipartite entanglement from local measurements, Gaussian bound entangled states with secure key, and various topics in quantum metrology

**University of Birmingham**, Birmingham, UK

2018-2019

*Master of Research, Translational Quantum Technology*

- Advisors: [Haixing Miao](#) and [Vincent Boyer](#)
- Thesis title: Broadband Quantum Noise Reduction in Future Long Baseline Gravitational-wave Detectors via EPR Entanglement and The Quantum Limits of Beam Displacement Measurements

**Clarion University of Pennsylvania**, Clarion, PA

2015-2018

*Bachelor of Science, Physics and Mathematics*

## RESEARCH

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**Graduate Researcher**, JILA/University of Colorado, Boulder

2019-PRESENT

*Quantum information theory under Graeme Smith*

- Working primarily on hardware-efficient entanglement quantification (e.g. [\[PR9\]](#)), and topics in quantum metrology (e.g. [\[PR8\]](#))

- Graduate Researcher**, Los Alamos National Lab 2020-2021  
*Quantum algorithms and quantum info theory under Patrick Coles*
- Developed a near-term quantum algorithm for estimating the mixed state quantum Fisher information (see [PR6])
  - Introduced a generalized measure of quantum Fisher information (see [PR5])
  - Proved several properties of computable lower bound on QFI (see [PR3])
  - Defined a general family of multipartite entanglement measures computable on current quantum hardware (see [PR4])
- Graduate Researcher**, University of Birmingham 2018-2019  
*Quantum optics theory under Haixing Miao and Vincent Boyer*
- Worked on the theory and simulation of EPR-based quantum noise reduction for future gravitational-wave detectors (see [PR1] and thesis on [LinkedIn](#))
- DOE SULI Student**, Oak Ridge National Lab SUMMER 2018  
*Quantum optics theory under Raphael Pooser*
- Explored the theory of truncated nonlinear interferometers and their ability to surpass the standard quantum limit of beam displacement measurements (see [PR2])
- NSF REU Student**, University of Birmingham SUMMER 2017  
*Quantum optics theory under Haixing Miao and Andreas Freise*
- Worked within LIGO theory group to model ponderomotive squeezing – a method of surpassing the standard quantum limit of an interferometer
- Undergrad Researcher**, Clarion University of Pennsylvania 2016  
*Observational astronomy under advisor Sharon Montgomery*
- Undergrad Researcher**, Clarion University of Pennsylvania 2015-2016  
*Physics education research under advisor Vasudeva Aravind*

## PUBLICATIONS ([GOOGLE SCHOLAR PAGE](#)) ([PAPERS ON ARXIV](#))

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### PEER-REVIEWED ARTICLES

- [PR9] **Jacob L. Beckey**, Gregory Pelegrí, Steph Foulds, Natalie J. Pearson. Multipartite entanglement measures via Bell basis measurements. *Phys. Rev. A* **107**, 062425, Jun 2023
- [PR8] Anthony M. Polloreno, **Jacob L. Beckey**, Joshua Levin, Ariel Shlosberg, James K. Thompson, Michael Foss-Feig, David Hayes, Graeme Smith. Opportunities and Limitations in Broadband Sensing. *Phys. Rev. Applied* **19**, 014029, Jan 2023.
- [PR7] E. Fradgley, C. French, L. Rushton, Y. Dieudonné, L. Harrison, **J. L. Beckey**, H. Miao, C. Gill, P.G. Petrov, V. Boyer. Quantum limits of position-sensitive photodiodes. *Optics Express*, Vol. 30, Issue 22, pp. 39374-39381 (2022).
- [PR6] **Jacob L. Beckey**, Akira Sone, M. Cerezo, Patrick J. Coles. Variational Quantum Algorithm for Estimating the Quantum Fisher Information. *Phys. Rev. Research* **4**, 013083, Feb 2022.

- [PR5] Akira Sone, M. Cerezo, **Jacob L. Beckey**, Patrick J. Coles. A Generalized Measure of Quantum Fisher Information. *Phys. Rev. A* 104, 062602, Dec 2021
- [PP4] **Jacob L. Beckey**, N. Gigena, Patrick J. Coles, and M. Cerezo. Computable and operationally meaningful multipartite entanglement measures. *Phys. Rev. Lett.*, 127:140501, Sept 2021.
- [PR3] M. Cerezo, Akira Sone, **Jacob L. Beckey**, Patrick J. Coles. Sub-Quantum Fisher Information. *Quantum Sci. Technol.* 6 035008, Jun 2021
- [PR2] R. C. Pooser, N. Savino, E. Batson, **J. L. Beckey**, J. Garcia, and B. J. Lawrie. Truncated nonlinear interferometry for quantum-enhanced atomic force microscopy. *Phys. Rev. Lett.*, 124:230504, Jun 2020.
- [PR1] **Jacob L. Beckey**, Yiqiu Ma, Vincent Boyer, and Haixing Miao. Broadband quantum noise reduction in future long baseline gravitational-wave detectors via EPR entanglement. *Phys. Rev. D*, 100:083011, Oct 2019.

## PRESENTATIONS

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### INVITED TALKS

- QOQMS Group Seminar, University of Strathclyde, 2022
  - “Controlled-SWAP Test and Entanglement Monotones”
- Quantum Light and Matter Group Seminar, Durham University, 2022
  - “Controlled-SWAP Test and Entanglement Monotones”
- QuFITS Seminar, University of York, 2022
  - “Controlled-SWAP Test and Entanglement Monotones”
- Quantum Information Group Seminar, Universitat Autònoma de Barcelona, 2022
  - “Controlled-SWAP Test and Entanglement Monotones”
- Aliro Technologies Seminar, 2021
  - “Near-term Quantum Algorithm for Quantum Sensor Evaluation”

### CONTRIBUTED TALKS

- American Physical Society’s March Meeting, 2021
  - “Near-term Quantum Algorithm for Quantum Sensor Evaluation”
- American Physical Society’s March Meeting, 2016
  - “First-order Error Corrections in Introductory Physics Lab”

### POSTERS

- Theory of Quantum Computation, Cryptography, and Communication (TQC), 2023
  - “Local strategies for multipartite entanglement quantification”
- Quantum Information Processing (QIP), 2023
  - “Multipartite entanglement measures via Bell basis measurements”
- Quantum Information Processing (QIP), 2022
  - “Computable and operationally meaningful multipartite entanglement measures”

- Quantum Science Center’s Postdoctoral and Graduate Student Association Inaugural Poster Session, 2021
  - “Near-term Quantum Algorithm for Quantum Sensor Evaluation”
- Quantum Information Processing (QIP), 2021
  - “Variational Quantum Algorithm for Quantum Sensor Evaluation”
- Les Houches Ecole des Physique Pre-doctoral School, 2019
  - “Broadband Quantum Noise Reduction in Einstein Telescope via EPR Entanglement”
- ORNL Summer Research Participant Poster Session, 2018
  - “Generalization of Interferometry and Beam Position Measurement Equivalence”
- American Astronomical Society’s 231st Meeting, 2018
  - “Modeling Ponderomotive Squeezed Light in Gravitational-wave Interferometers”
- American Astronomical Society’s 229th Meeting, 2017
  - “Mapping the Heiles Supershell GSH 90-28-17”

## TEACHING

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**Lecturer**, PHYS/CSCI 3090: Introduction to Quantum Computing SPRING 2022  
*University of Colorado, Boulder; 75 students*

**Instructor**, PHYS1400: The Fundamentals of Scientific Inquiry FALL 2022  
*University of Colorado, Boulder; 18 students*

## ACADEMIC SERVICE

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### Committee Service

**CUbit Education & Workforce Development Steering Committee**, University of Colorado 2023-PRESENT  
*Helping develop quantum education and workforce development initiatives across campus.*

### Referee Service

- [Quantum](#) (3 articles)
- [QIP](#) (3 submissions)

## SCHOOLS AND WORKSHOPS

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**Kavli Institute for Theoretical Physics**, Santa Barbara, California 2023  
*New Directions in Quantum Metrology*

**University of Copenhagen**, Copenhagen, Denmark 2023  
*QMath Masterclass: Quantum Learning Theory*

**University of Colorado, Boulder**, Boulder, Colorado 2023  
*Meeting of the Simons Collaboration on Ultra-Quantum Matter*

**University of Illinois, Urbana-Champaign**, Chicago, Illinois 2022  
*Quantitative Linear Algebra meets Quantum Info Theory II*

**Les Houches Ecole des Physique**, Les Houches, France 2019  
*Light-matter interaction in dilute media and individual quantum systems*

## AWARDS

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Title	Duration
CU Physics Award for TA Excellence	Spring 2023
U.S. DOE Office of Science Graduate Research Award (SCGSR)	Spring 2023
LANL Quantum Computing Summer School Fellowship	Summer 2020
NSF Graduate Research Fellowship	2019-2021
Fulbright - University of Birmingham Postgraduate Award	2018-2019
France-Allison Honors Scholarship	2017-2018
Clarion International Scholar Award	Summer 2017
William and Elizabeth Hart STEM Scholarship	2017-2018
Helen and Lawrence Smith STEM Scholarship	2017-2018
Clarion Honors Foundation Scholarship	2015-2018
Clarion Academic Scholarship	2015-2018
Board of Governors Full Tuition Scholarship	2015-2018
David C. Smith Honors Scholarship	2015-2018
Karl Sandler Freshman Physics Award	2015-2016

## OUTREACH

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**Co-founder and Vice President**, Idealized Science Institute 2023-PRESENT  
*McKees Rocks, PA*

- Educational non-profit empowering physics educators across the country to engage in research-backed educational practices

**Mentor**, Partnerships for Informal Science in the Community (PISEC) FALL 2023  
*Boulder, CO*

- Guiding elementary students through informal, exploratory science activities weekly

**Mentor**, Graduate Association of Students in Physics (GASP) 2021-PRESENT  
*Boulder, CO*

- Closely mentoring graduate students to help them transition to graduate physics education and research. Running mentorship program as of May 2023.

**Lecturer**, Freedom Area Senior High School

2020-2021

*Virtual*

- Lecturing once per week to advance students on topics in theoretical physics and providing mentorship on college applications, life in physics, etc.

**Mentor**, CU Prime

2019-PRESENT

*Boulder, CO*

- Mentor undergraduate physics students on a monthly basis
- Mentored a small group of students in an introductory nature of science course (Fall 2019).

**Presenter**, Pierce Planetarium

2016-2018

*Clarion, PA*

- Narrated monthly educational planetarium shows for students and community members

**Tutor**, Community Learning Workshop

2016-2017

*Clarion, PA*

- Assisted young students from surrounding schools learn math and physics multiple times per week

## TECHNICAL SKILLS

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- **Programming languages:** Mathematica and Python
- **Quantum computing packages:** Qiskit, QuTip, Quantum Mathematica