Joshuah T. Heath

Postdoctoral Research Associate
Condensed matter & quantum information theory
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Education

June 2021 Ph.D. in Physics,
Boston College, Chestnut Hill, MA, USA
Field: Theoretical Condensed Matter Physics | Advisor: Kevin S. Bedell
Thesis: *Novel metallic behavior in topologically non-trivial, quantum critical, and low-dimensional matter*
Committee: Kevin S. Bedell, Fazel Tafti, Jan Engelbrecht, Xiao Chen

May 2017 M.Sc. in Physics,
Boston College, Chestnut Hill, MA, USA

May 2015 B.Sc. in Mathematics, with honors, *cum laude*
University of Vermont, Burlington, VT, USA

May 2015 B.Sc. in Physics, with honors
University of Vermont, Burlington, VT, USA

Employment

Aug 2024–Present Postdoctoral Research Associate
Nordic Institute for Theoretical Physics, Stockholm University & **University of Connecticut**, Dept. of Physics
Stockholm, Sweden & Storrs, Connecticut, USA
Research Group of Alexander Balatsky

Aug 2021–July 2024 Postdoctoral Research Associate
Dartmouth College, Dept. of Physics and Astronomy
Hanover, New Hampshire, USA
Research Groups of Rufus Boyack, Lorenza Viola, & James Whitfield

Aug 2015–July 2021 Graduate Research & Teaching Assistant
Boston College, Dept. of Physics
Chestnut Hill, Massachusetts, USA
Research Group of Kevin S. Bedell

Scholarships, Awards, & Recognitions

Oct 2020/Nov 2022 IOP Trusted Reviewer Status (top 15% of referees for IOP Publishing)
March 2021 IOP Outstanding Reviewer for Physica Scripta for 2020
April 2017 Donald J. White Teaching Excellence Award
May 2013/14/15 UVM Mathematics Sophomore, Junior, & Senior Awards
May 2014 Mortar Board Senior Honors Society
May 2013 Sigma Pi Sigma Physics Honor Society
June 2011 Vermont Scholar's Award

Scientific Background, Interests, & Achievements

General

- Condensed matter theory and quantum information science

Specific

- Eliashberg theory of electron-phonon superconductors; Experimental signatures of topologically non-trivial phases of matter; Simulation complexity in quantum circuits and phases of matter; Electronic transport in non-equilibrium phases of matter; Breakdown of Landau-Fermi liquid theory

Milestones

- Theory of Homes scaling in electron-phonon superconductors (w/Rufus Boyack)
- Identification of classically simulable quantum circuits whose output states exhibit Wigner-Dyson entanglement level statistics (w/Andrew Projansky)
- Theoretical prediction (and experimental verification) of Majorana-like excitations in the specific heat of a novel spin liquid candidate (w/groups of Fazel Tafti & Roman Movshovich)
- Proposed necessary and sufficient conditions under which general interacting fermionic system will obey Luttinger's theorem (w/Kevin Bedell)

Teaching Background

Past

- Graduate teaching assistant for non-physics major and physics major undergraduate classes; duties include recitations, homework grading, test grading, quiz administration, homework help, and occasionally substitute lecturer for classes of up to 100+ students
- Graduate teaching assistant for graduate-level physics classes; duties include homework grading, test grading, and homework help
- Graduate teaching assistant for undergraduate physics and non-physics major laboratory; duties include lab report grading, lab quiz grading, and setting up labs
- Undergraduate teaching assistant for undergraduate physics, math, and philosophy courses; duties ranged from general assistance and coding help to grading of homework sets and exams.

Outreach

April 2023, April 2024	Volunteer for Dartmouth Science Day | Physics demos on magnetism and superconductivity for K-12 students Dartmouth College, Hanover, NH, USA
Nov. 2018, March 2021	Volunteer Lecturer for BC Splash | Mini-courses on special and general relativity & quantum computing for high school students Boston College, Chestnut Hill, MA, USA
Nov. 2011–April 2015	Volunteer Science Educator | Physics demos to K-12 students and professionals ECHO Lake Aquarium and Science Center, Burlington, VT, USA

Professional Activities and Service

2020-Present	Referee | Journal of Physics: Condensed Matter (5 papers), Physical Review B (3 papers), Physica Scripta (3 papers), Journal of Physics A (2 papers), Physical Review Letters (2 papers), Journal of Physics G (1 paper), Journal of Physics: Materials (1 paper)
2021-2024	Organizer | Dartmouth Quantum/Nano Hybrid Seminar Series
2023	Session Chair | APS March Meeting (Virtual) 2023
2021	Organizer | Quantum Computation in Isolation Virtual Seminar Series
2020-2021	Organizer | Quantum Fluids in Isolation Virtual Seminar Series
2018–2019	Organizer | Emerging Results Seminar Series, Boston College Physics Dept.
2016–2017	Representative | BC Physics Dept. Grad Affairs & Teaching Committees
2015–Present	Member |International Society for Relativistic Quantum Information
2013–Present	Member |American Physical Society

Mentoring

Past

- Andrew Projansky \| Ph.D. student, Dartmouth College
  Jan. 2023–April 2024
  - ◇ Project: Entanglement spectrum statistics in fermionic circuits
  - ◇ Current Position: Ph.D. student at Dartmouth College.

- Joseph Gibson \| M.S. student, Dartmouth College
  Jan. 2023–Feb. 2024
  - ◇ Project: Measurement-induced phase transitions in noisy circuits
  - ◇ Current Position: Ph.D. student at Université de Sherbrooke

- Roy Forestano \| Undergrad researcher, Boston College
  Jan. 2019–April 2021
  - ◇ Project: Unconventional superconductivity in itinerant ferromagnets
  - ◇ Current Position: Ph.D. student at University of Florida

- Luke Martin \| Undergrad researcher, Boston College
  Jan. 2019–April 2021
  - ◇ Project: KSS viscosity bound in ultra-massive hairy black holes
  - ◇ Current Position: Ph.D. student at University of New Hampshire

- Adeyemi Lawal \| Undergrad researcher, Boston College
  July–Aug. 2018
  - ◇ Project: Basics of quantum statistical mechanics
  - ◇ Current Position: Software engineer

- Paul Menker \| Undergrad researcher, Boston College
  Jan.–April 2018
  - ◇ Project: Basics of conformal field theory and its relation to holography
  - ◇ Current Position: Ph.D. student at University of Southern California

Technical Skills

Fluency:	Julia, Python, Mathematica, Linux, MacOS, LaTeX
Basic Knowledge:	BASH, MATLAB, HTML, C++

Publications & Preprints

In Preparation

- **Joshuah T. Heath**, Vincent Flynn, Andrew Cupo, Emilio Cobanera, James Whitfield, Lorenza Viola |"Engineering a Quantized Integer Hall Response in Non-Interacting Bosonic Hamiltonians"
  Manuscript available upon request | arXiv TBA | To be submitted to PRB

- **Joshuah T. Heath** |"Fermi Liquids in the Absence of Charge Quantization"
  Manuscript in preparation | arXiv TBA

2024

- **Joshuah T. Heath** & Rufus Boyack |"Universal scaling relations in electron-phonon superconductors"
  Submitted to *Physical Review Letters* | arXiv TBA

2023

- Andrew M. Projansky, **Joshuah T. Heath** & James D. Whitfield |"Entanglement spectrum of matchgate circuits with universal and non-universal resources"
  Under review at *Quantum* | arXiv:2312.08447

- **Joshuah T. Heath**, Faranak Bahrami, Roman Movshovich, Xiao Chen, Fazel Tafti, & Kevin S. Bedell |"Signatures of a Majorana-Fermi surface in the Kitaev magnet $Ag_3LiIr_2O_6$"
  Commun. Phys. **6**, 348 (2023) | arXiv:2108.03246

- Andrew Cupo, **Joshuah T. Heath**, Emilio Cobanera, James Whitfield, Chandrasekhar Ramanathan, Lorenza Viola |"Optical Conductivity Signatures of Floquet Electronic Phases"
  Phys. Rev. B **108**, 024308 (2023) | arXiv:2303.02261

2022

- James D. Whitfield, Jun Yang, Weishi Wang, **Joshuah T. Heath**, Brent Harrison |"Quantum Computing 2022"
  arXiv:2201.09877

2021

- **Joshuah T. Heath** & Kevin S. Bedell |"Gauging away the Stoner model: Engineering unconventional metallic ferromagnetism with artificial gauge fields"
  Submitted to SciPost Physics | arXiv:2008.07535

2020

- **Joshuah T. Heath** & Kevin S. Bedell |"Universal Signatures of Majorana-like Quasiparticles in Strongly Correlated Landau-Fermi Liquids"
  J. Phys.: Condens. Matter **32** 485602 (2020) | arXiv:1903.00619

- **Joshuah T. Heath** |"Landau Quasiparticles in Weak Power-Law Liquids"
  J. Low Temp. Phys. **201**, 200-212 (2020) | arXiv:2001.08230

- **Joshuah T. Heath** & Kevin S. Bedell |"Necessary and Sufficient Conditions for the Validity of Luttinger's Theorem"
  New J. Phys. **22** 06301 (2020) | arXiv:1906.00929

- **Joshuah T. Heath**, Matthew P. Gochan, and Kevin S. Bedell |"Chebyshev polynomial expansion of two-dimensional Landau-Fermi liquid parameters"
  J. Phys. A: Math. Theor. **53** 225203 (2020) | arXiv:1912.03427

- Matthew P. Gochan, **Joshuah T. Heath**, & Kevin S. Bedell | "Atypical Behavior of Collective Modes in Two-Dimensional Fermi Liquids"
  J. Phys.: Condens. Matter **32** 345602 (2020) | arXiv:1912.02699

2019

- **Joshuah T. Heath** & Kevin S. Bedell |"Exotic quantum statistics and thermodynamics from a number-conserving theory of Majorana fermions"
  J. Phys. A: Math. Theor. **52** 315001 (2019) | arXiv:1709.04483

2016

- Kenneth I. Golden & **Joshuah T. Heath** |"Generalized Nonlinear Fluctuation-Dissipation Relation for the One-Component Plasma"
  J. Stat. Phys. **162**, 199-217 (2016)

2014

- Kenneth I. Golden & **Joshuah T. Heath** |"Hierarchy of Fluctuation-Dissipation Theorems for the Classical One-Component Plasma"
  Contributions to Plasma Physics, **X**, 1-7 (2014)| arXiv:1410.4889

Invited Talks

2024

- "Universal physics in strongly interacting superconductors" (work done w/Rufus Boyack)
  - ◇ Colloquium, Maynooth University
    Maynooth, Republic of Ireland. May 17th, 2024
- " Universal electromagnetic properties of strongly coupled electron-phonon superconductors" (work done w/Rufus Boyack)
  - ◇ Seminar, Dublin Institute for Advanced Study (DIAS)
    Dublin, Republic of Ireland. May 15th, 2024

2023

- "Electromagnetic properties and μSR relaxation rate of Eliashberg superconductors in the weak and strong-coupling limits" (work done w/Rufus Boyack)
  - ◇ Virtual seminar, Nordic Institute for Theoretical Physics (Nordita)
    Stockholm, Sweden (talk given virtually). May 23rd, 2023
- "Engineering a Quantized Integer Hall Response in Non-Interacting Bosonic Hamiltonians" (work done w/Vincent Flynn, Andrew Cupo, Emilio Cobanera, & Lorenza Viola)
  - ◇ Seminar, Institut quantique de l'Université de Sherbrooke
    Sherbrooke, Québec, Canada. April 19th, 2023

2021

- "The Marriage of Heaven and Hell: Kitaev Materials at the Crossroads of Theory and Experiment" (work done w/Faranak Bahrami, Sangyun Lee, Roman Movshovich, Xiao Chen, Fazel Tafti, & Kevin Bedell)
  - ◇ Virtual seminar, Dartmouth College
    Hanover, New Hampshire, USA (talk given virtually). Feb. 25th, 2021

2020

- "Luttinger's Theorem: The first 60 years" (work done w/Kevin Bedell)
  - ◇ Virtual seminar, K. Hazzard's group at Rice University
    Houston, Texas, USA (talk given virtually). July 20th, 2020

2018

- "Majorana Lives! Many-body Majorana physics beyond the anyonic paradigm" (work done w/Kevin Bedell)
  - ◇ Seminar, Condensed Matter Theory Kids, Harvard University
    Cambridge, Massachusetts, USA. Oct. 10th, 2018

2014

- "Floquet realization of unconventional superconductivity in periodically driven fermionic systems" (work done w/Marin Bukov & Anatoli Polkovnikov)
  - ◇ Seminar, A. Polkovnikov's group at Boston University
    Boston, Massachusetts. Nov. 3rd, 2014

Contributed Presentations and Posters

2024

- "Universal physics in strongly interacting superconductors" (work done w/Rufus Boyack)
  - ◇ Poster, Gordon Research Conference on Correlated Electron Systems
    South Hadley, Massachusetts, USA.
    June 24th, 2024
- "Universal scaling relations in electron-phonon superconductors" (work done w/Rufus Boyack)
  - ◇ Presentation, APS March Meeting
    Minneapolis, Minnesota, USA. March 4th, 2024
- "Numerical implementation of the Eliashberg equations on the imaginary axis at strong coupling" (work done w/Rufus Boyack)
  - ◇ Poster, APS March Meeting
    Minneapolis, Minnesota, USA. March 7th, 2024

2023

- "Engineering a Quantized Integer Hall Response in Non-Interacting Bosonic Hamiltonians" (work done w/Vincent Flynn, Andrew Cupo, Emilio Cobanera, & Lorenza Viola)
  - ◇ Virtual presentation, APS March Meeting
    Las Vegas, Nevada, USA (talk given virtually). March 21st, 2023

2022

- "Fermi liquids in the absence of charge quantization"
  - ◇ Virtual presentation, APS March Meeting
    Chicago, Illinois, USA (talk given virtually). March 17th, 2022
- "The Interplay of Fermi liquid theory and Luttinger's theorem in strongly correlated materials"
  - ◇ Virtual poster, APS March Meeting
    Chicago, Illinois, USA (talk given virtually). March 15th, 2022

2021

- "Novel metallic behavior in topologically non-trivial, quantum critical, and low-dimensional matter" (includes work done w/Faranak Bahrami, Kevin Bedell, Xiao Chen, Matthew Gochan, Sangyun Lee, Roman Movshovich, & Fazel Tafti)
  - ◇ Doctoral thesis defense at Boston College
    Chestnut Hill, Massachusetts, USA. June 16th, 2021
- "Luttinger's Theorem-Violating Fermi Liquids and Power-law Green's Functions" (includes work done w/Kevin Bedell)
  - ◇ Virtual presentation, Princeton Summer School on Condensed Matter Physics
    Princeton, New Jersey, USA (talk given virtually). June 10th, 2021

- "How useful are quantum computers? Quantum advantage for high school student"
  - ◇ Virtual presentation, Boston College Splash Outreach to local high school students
    Chestnut Hill, Massachusetts, USA (talk given virtually).
    March 28th, 2021

- "Gauging away the Stoner model: Engineering unconventional metallic ferromagnetism with artificial gauge fields" (work down w/Kevin Bedell)
  - ◇ Virtual presentation, APS March Meeting
    Remote conference, March 18, 2021

- "Evidence of a weakly-correlated Majorana liquid in the Kitaev magnet Ag3LiIr2O6" (work done w/Faranak Bahrami, Sangyun Lee, Roman Movshovich, Xiao Chen, Kevin Bedell, & Fazel Tafti)
  - ◇ Virtual presentation, APS March Meeting
    Remote conference, March 16, 2021

- "Evidence of a Majorana-Fermi surface in the Kitaev magnet $Ag_3LiIr_2O_6$" (work done w/Faranak Bahrami, Roman Movshovich, Xiao Chen, Fazel Tafti, & Kevin Bedell)
  - ◇ Virtual presentation, waiting for the conference on Highly Frustrated Magnetism
    Max Planck Institute for the Physics of Complex Systems, Dresden, Germany (talk given virtually). Jan. 27th, 2021
  - ◇ Virtual presentation, MagLab Theory Winter School
    National High Magnetic Field Laboratory, Tallahassee, Florida, USA (talk given virtually). Jan. 12th, 2021

2020

- "Landau quasiparticles in weak power-law liquids" (includes work done w/Kevin Bedell)
  - ◇ Virtual presentation, Speakers' Corner seminar
    Virtual Science Forum. November 17th, 2020

- "Observation of a weakly-correlated Majorana liquid in the silver-lithium iridate $Ag_3LiIr_2O_6$" (work done w/Faranak Bahrami, Fazel Tafti, Roman Movshovich, and Kevin Bedell)
  - ◇ Virtual presentation, Princeton Summer School on Condensed Matter Physics
    Princeton, New Jersey, USA (talk given virtually). June 12th, 2020

- "The Hunting of the Snark: Generic Conditions for Luttinger's Theorem in Strongly Correlated Systems" (work done w/Kevin Bedell)
  - ◇ Presentation, Boston College Dept. of Physics Mini-March Meeting
    Chestnut Hill, Massachusetts, USA. March 4th, 2020

2019

- "The Hunting of the Snark: Generic Conditions for Luttinger's Theorem in Strongly Correlated Systems" (work done w/Kevin Bedell)
  - ◇ Presentation, 21st Annual Greater Boston Area Statistical Mechanics Meeting (GBASM)
    Waltham, Massachusetts, USA. Oct. 19th, 2019

- "Exotic quantum statistics from a many-body theory of Majorana fermions" (work done w/Kevin Bedell)
  - ◇ Poster, APS March Meeting
    Boston, Massachusetts, USA. March 6th, 2019

- "Collective Excitations in a Landau-Majorana Liquid" (work done w/Kevin Bedell)
  - ◇ Presentation, APS March Meeting
    Boston, Massachusetts, USA. March 6th, 2019

2018

- "Fermi Liquids from Spin Liquids" (work done w/Kevin Bedell)
  - ◇ Presentation, Emerging Results Seminar at Boston College
    Chestnut Hill, Massachusetts, USA. Nov. 28th, 2018

- "Majorana Lives! Many-body Majorana physics beyond the anyonic paradigm" (work done w/Kevin Bedell)
  - ◇ Presentation, 20th Annual Greater Boston Area Statistical Mechanics Meeting (GBASM)
    Waltham, Massachusetts, USA. Oct. 27th, 2018

- "Majorana Physics beyond the anyonic paradigm: Towards a Landau-Majorana liquid theory" (work done w/Kevin Bedell)
  - ◇ Poster, Gordon Research Seminar and Conference on Correlated Electron Systems
    South Hadley, Massachusetts, USA
    June 23th–June 29th, 2018

2017

- "Exotic quantum statistics from a many-body theory of Majorana fermions" (work done w/Kevin Bedell)
  - ◇ Poster, Majorana Fermions & Beyond Workshop
    Yale Quantum Institute, Hartford, Connecticut, USA. Oct. 27th, 2017
  - ◇ Presentation, 19th Annual Greater Boston Area Statistical Mechanics Meeting (GBASM)
    Cambridge, Massachusetts, USA. Oct. 21st, 2017

2015

- "Pressure-energy relation in canonical 2D dipolar bosons: A path integral Monte Carlo study " (work done w/Adrian Del Maestro)
  - ◇ Presentation, New England APS Spring Meeting
    Boston, Massachusetts, USA. April 24th, 2015
  - ◇ Presentation, Student Research Conference at University of Vermont
    Burlington, Vermont, USA. April 23rd, 2015
- "Suppression of conventional pairing in Floquet engineered fermionic systems" (work done w/Marin Bukov & Anatoli Polkovnikov)
  - ◇ Presentation, Condensed Matter Theory Seminar at University of Vermont
    Burlington, Vermont, USA. March 12th, 2015

2014

- "Hierarchy of fluctuation-dissipation theorems for the classical one-component plasma" (work done w/Kenneth Golden)
  - ◇ (poster given by Kenneth Golden) Poster, International Conference on Strongly Coupled Coulomb Systems
    Santa Fe, New Mexico, USA. July 29th, 2014
- "Hierarchy in the static fluctuation-dissipation theorem of one-component plasmas" (work done w/Kenneth Golden)
  - ◇ Poster, Student Research Conference at University of Vermont
    Burlington, Vermont, USA. April 16th, 2014
  - ◇ Poster, New England APS Spring Meeting
    Chestnut Hill, Massachusetts, USA. April 4th, 2014

2013

- "Computational study of ferromagnetic phase transitions in the Ising and XY models via the Monte Carlo method" (work done w/Adrian Del Maestro)
  - ◇ Poster, Student Research Conference at University of Vermont
    Burlington, Vermont, USA. April 23rd, 2013
- "The Kosterlitz-Thouless transition: Complexity in the XY-Model" (work done w/Adrian Del Maestro)
  - ◇ Presentation, Student Complexity Research and Pizza Seminar at University of Vermont
    Burlington, Vermont, USA. Feb. 4th, 2013