

Zachary M. Raines

CONDENSED MATTER THEORY POSTDOCTORAL ASSOCIATE

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Education

University of Maryland, College Park

PH.D. IN PHYSICS

College Park, Maryland

Aug. 2011 - Aug. 2019

Boston University

B.A. IN PHYSICS

Boston, Massachusetts

Aug. 2007- May 2011

Research Interests

Superconductivity	Unconventional superconductivity and collective modes of superconductors
Non-equilibrium systems	Novel methods of utilizing and enhancing superconductivity out of equilibrium
Light-matter hybridization	Cavity polaritons and collective mode hybridization
Quantum Geometry	Band and Hilbert space geometry effects on observables of many body systems
Weyl and Dirac systems	Phenomena in linearly dispersing electronic media
Kinetic theory	Interplay of kinetics and Hilbert space geometry

Research Experience

University of Minnesota, Twin Cities, William I Fine Theoretical Physics Institute

POSTDOCTORAL ASSOCIATE

Minneapolis, MN

2022-Present

- Geometric aspects of kinetic theory with Prof. Alex Kamenev.
- Aspects of quantum critical superconductivity and isospin symmetry breaking in multi-valley 2D materials with Prof. Andrey Chubukov.

Yale University

POSTDOCTORAL ASSOCIATE

New Haven, Connecticut

2019-2022

- Characterization of the neutral collective modes of the graphene electron liquid including the effect of Hilbert space geometry with Prof. Leonid Glazman.

University of Maryland, College Park, Condensed Matter Theory Center (CMTC) and Joint Quantum Institute (JQI)

GRADUATE RESEARCH ASSISTANT

College Park, Maryland

2012 - 2019

- Theoretical investigation of the interplay between ordered states in high temperature superconductors as well the effects of coupling photonic cavities to superconductor under Prof. Victor Galitski.

University of Maryland, College Park, Institute for Physical Science and Technology (IPST)

GRADUATE RESEARCH ASSISTANT

College Park, Maryland

2012

- Theoretical investigation of the Local Molecular Field theory of water under Prof. John Weeks.

Boston University

INDEPENDENT WORK FOR DISTINCTION

Boston, Massachusetts

2011

- Detailed simulation work to determine the properties of the light collection subsystem for the NEDM experiment. Work includes determination of total transmission, form of the experimental signal, and simulation of noise in the experiment.

Boston University Physics Department, Medium Energy Group

RESEARCH ASSISTANT

Boston, Massachusetts

2009-2011

- Data acquisition and simulation in development of the light collection subsystem for the Neutron Electric Dipole Moment experiment at the Spallation Neutron Source at Oak Ridge National Laboratory under Prof. B. Lee Roberts and Prof. James Miller.

University of Pennsylvania HEP Instrumentation Group

Philadelphia, Pennsylvania

RESEARCH ASSISTANT

2008

- Research and prototyping work under Richard van Berg in the development of more sensitive positron emission tomography(PET) technology.

Honors & Awards

2019-	Yale Prize Postdoctoral Fellowship , Yale University	New Haven, Connecticut
2011	University Fellowship , University of Maryland	College Park, Maryland
2011	Physics Alumni Award , Boston University	Boston, Massachusetts
2011	Summa cum Laude , Boston University	Boston, Massachusetts
2010	Inductee , Phi Beta Kappa Society, Epsilon of Massachusetts	Boston, Massachusetts
2010	Member , Boston University Metcalf Award selection committee	Boston, Massachusetts
2010	Harold Case Scholarship for Academic Excellence , Boston University College of Arts and Sciences	Boston, Massachusetts

Papers & Publications

Under Review

- [1] S.-S. Zhang, Z. M. Raines, and A. V. Chubukov, *Applicability of Eliashberg theory for systems with electron-phonon and electron-electron interaction: a comparative analysis*, Apr. 2024, arXiv:2404.11820 [cond-mat].

Published in Peer Reviewed Journals

- [1] Z. M. Raines, S.-S. Zhang, and A. V. Chubukov, “Superfluid stiffness within Eliashberg theory: The role of vertex corrections”, *Phys. Rev. B* **109**, 144505 (2024).
- [2] V. D. Kurilovich, Z. M. Raines, and L. I. Glazman, “Disorder-enabled Andreev reflection of a quantum Hall edge”, *Nature Communications* **14**, 2237 (2023).
- [3] Z. M. Raines, D. L. Maslov, and L. I. Glazman, “Spin-valley Silin modes in graphene with substrate-induced spin-orbit coupling”, *Physical Review B* **105**, L201201 (2022).
- [4] Z. M. Raines, V. I. Fal’ko, and L. I. Glazman, “Spin-valley collective modes of the electron liquid in graphene”, *Phys. Rev. B* **103**, 075422 (2021).
- [5] H. Dehghani, Z. M. Raines, V. M. Galitski, and M. Hafezi, “Optical enhancement of superconductivity via targeted destruction of charge density waves”, *Phys. Rev. B* **101**, 224506 (2020).
- [6] Z. M. Raines, A. A. Allocca, M. Hafezi, and V. M. Galitski, “Cavity Higgs polaritons”, *Phys. Rev. Research* **2**, 013143 (2020).
- [7] A. A. Allocca, Z. M. Raines, J. B. Curtis, and V. M. Galitski, “Cavity superconductor-polaritons”, *Phys. Rev. B* **99**, 020504 (2019).
- [8] J. B. Curtis, Z. M. Raines, A. A. Allocca, M. Hafezi, and V. M. Galitski, “Cavity Quantum Eliashberg Enhancement of Superconductivity”, *Phys. Rev. Lett.* **122**, 167002 (2019).
- [9] Z. M. Raines, A. A. Allocca, and V. M. Galitski, “Manifestations of spin-orbit coupling in a cuprate superconductor”, *Phys. Rev. B* **100**, 224512 (2019).
- [10] Z. M. Raines and V. M. Galitski, “Enriched axial anomaly in Weyl materials”, *Phys. Rev. B* **96**, 161115 (2017).
- [11] Z. M. Raines, V. Stanev, and V. M. Galitski, “Enhancement of superconductivity via periodic modulation in a three-dimensional model of cuprates”, *Phys. Rev. B* **91**, 184506 (2015).
- [12] Z. M. Raines, V. G. Stanev, and V. M. Galitski, “Hybridization of Higgs modes in a bond-density-wave state in cuprates”, *Phys. Rev. B* **92**, 184511 (2015).

Presented Works

Classical, quantum and active fluids – integrability, chaos, generalized hydrodynamics and turbulence

New York, NY

SPIN-VALLEY COLLECTIVE MODES OF THE ELECTRON LIQUID IN GRAPHENE

2024

Recent Advances in Superconductivity: Theory and Experiment

Gainesville, FL

SUPERFLUID STIFFNESS IN ELIASHBERG THEORY: THE ROLE OF VERTEX CORRECTIONS

2023

Quantum Materials With and Without Quasiparticles

Santa Barbara, CA

SUPERFLUID STIFFNESS IN ELIASHBERG THEORY: DYNAMIC INTERACTIONS AND EFFECTIVE GALILEAN INVARIANCE

2023

Department Seminar: University of Minnesota

Minneapolis, MN

SPIN VALLEY COLLECTIVE MODES OF THE ELECTRON LIQUID

2022

American Physical Society (APS), March Meeting

Online

SPIN VALLEY COLLECTIVE MODES OF THE ELECTRON LIQUID IN GRAPHENE

2021

Department Seminar: University of Manchester

Manchester, UK

SPIN VALLEY COLLECTIVE MODES OF THE ELECTRON LIQUID

2021

American Physical Society (APS), March Meeting

Boston, Massachusetts

CAVITY SUPERCONDUCTOR HIGGS-POLARITONS

2019

American Physical Society (APS), March Meeting

Los Angeles, California

ROLE OF INTERLAYER COUPLING ON THE COMPETITION BETWEEN BOND-DENSITY-WAVE ORDER AND SUPERCONDUCTIVITY

2018

Ultrafast Dynamics and Metastability

Georgetown, Washington, DC

ENHANCEMENT OF SUPERCONDUCTIVITY VIA PERIODIC MODULATION IN A THREE-DIMENSIONAL MODEL OF CUPRATES

2017

American Physical Society (APS), March Meeting

New Orleans, Louisiana

ELECTROMAGNETIC RESPONSE OF A WEYL SEMIMETAL WITH COEXISTING DENSITY WAVES

2017

American Physical Society (APS), March Meeting

Baltimore, Maryland

HYBRIDIZATION OF HIGGS MODES IN A BOND-DENSITY-WAVE STATE IN CUPRATES

2016

University of Maryland, Condensed Matter Theory Center Fall Symposium

College Park, Maryland

ENHANCEMENT OF SUPERCONDUCTIVITY VIA PERIODIC MODULATION IN A THREE-DIMENSIONAL MODEL OF CUPRATES

2015

American Physical Society (APS), March Meeting

San Antonio, Texas

ENHANCEMENT OF SUPERCONDUCTIVITY IN A THREE-DIMENSIONAL HOTSPOT MODEL OF COMPETING ORDERS IN THE CUPRATES

2015

American Physical Society (APS), March Meeting

Denver, Colorado

THE CASIMIR EFFECT ACROSS A SUPERCONDUCTING TRANSITION

2014