

Erhai Zhao

Associate Professor, Department of Physics and Astronomy
George Mason University, Fairfax, VA 22030
<http://ezhao.spacs.gmu.edu>
(703) 993-4571 ezhao2@gmu.edu

Education

Ph.D., Northwestern University, 2005

Advisor: James A. Sauls

Area of research: Superconductivity, quantum fluids

Thesis title: *Theory of nonequilibrium superconductivity near spin-active interfaces*

M.S., Fudan University, Shanghai, China, 1999

B.S., Fudan University, Shanghai, China, 1996

Appointments

Associate Professor, George Mason University 2015-present

Assistant Professor, George Mason University 2009-2015

Postdoc, University of Pittsburgh 2007-2009

Advisor: W. Vincent Liu

Area of research: Quantum gases, ultra-cold atoms

Postdoc, University of Toronto 2005-2007

Advisor: Arun Paramekanti

Area of research: Strongly correlated materials, quantum magnetism

RESEARCH

Research Interests

Condensed matter theory, many-body physics. Recent projects include

1. Fermi gases of ultracold atoms and molecules.
2. Topological phases of matter; periodically driven many-body systems.
3. Numerical many-body techniques: functional renormalization group, tensor networks.
4. Quantum devices of superconductors and topological insulators.

Research Grants

1. *Topological phases of ultracold atoms beyond standard optical lattices*
Air Force Office of Scientific Research (2015-2020)

2. *Dipolar Gas of Fermionic Molecules*
National Science Foundation (2012-2015)
3. *Optical Lattice Gases of Interacting Fermions*
Air Force Office of Scientific Research (2012-2015)
4. *Collaborative Theoretical Research on Fermi Degenerate Gases of Dysprosium*
Department of Commerce (2012-2013)
5. *MRI: Acquisition of Electron Beam Evaporation System for Multidisciplinary Research and Education*, National Science Foundation (2011-2014)
Co-PI (PI: Dr. Qiliang Li, Volgenau School of Engineering, George Mason University)

Publication Summary

- Total 35 papers, including 11 in PRL, 11 in PRB, and 7 in PRA.
- Total citation: over 1,000 (788 since 2011, Google Scholar)
- H-index: 19 (Google Scholar)
- ResearcherID: <http://www.researcherid.com/rid/B-3463-2010>
- Google Scholar: <http://scholar.google.com/citations?hl=en&user=GhUd77oAAAAJ>

Publications

Competing many-body instabilities in two-dimensional dipolar Fermi gases,
Ahmet Keles, Erhai Zhao
Phys. Rev. A 94, 033616 (2016).

Anatomy of a periodically driven p-wave superconductor,
Erhai Zhao
Zeitschrift fur Naturforschung A, 71(10), 883 (2016).

A continuum of compass spin models on the honeycomb lattice,
Haiyuan Zou, Bo Liu, Erhai Zhao, W. Vincent Liu
New J. Phys. 18 053040 (2016).

Spin-Orbital Exchange of Strongly Interacting Fermions in the p-Band of a Two-Dimensional Optical Lattice,
Zhenyu Zhou, Erhai Zhao, and W. Vincent Liu,
Phys. Rev. Lett. 114, 100406 (2015).

Floquet edge states in a harmonically driven integer quantum Hall system,
Zhenyu Zhou, Indubala I. Satija, and Erhai Zhao,
Phys. Rev. B 90, 205108 (2014).

SnTe field effect transistors and the anomalous electrical response of structural phase transition,

Haitao Li, Hao Zhu, Hui Yuan, Lin You, Curt A. Richter, Joseph J. Kopanski, Erhai Zhao, and Qiliang Li,
Applied Physics Letters 105, 013503 (2014).

Counter-propagating Edge Modes and Topological Phases of a Kicked Quantum Hall System,
Mahmoud Lababidi, Indubala I. Satija, and Erhai Zhao,
Phys. Rev. Lett. 112, 026805 (2014).

Topological Insulator Bi_2Se_3 Nanowire High Performance Field-Effect Transistors,
Hao Zhu, Curt A. Richter, Erhai Zhao, John E. Bonevich, William A. Kimes, Hyuk-Jae Jang, Hui Yuan, Haitao Li, Abbas Arab, Oleg Kirillov, James E. Maslar, Dimitris E. Ioannou, and Qiliang Li,
Scientific Reports 3, 1757 (2013).

Topological states in a ladder-like optical lattice containing ultracold atoms in higher orbital bands,
Xiaopeng Li, Erhai Zhao, and W. Vincent Liu,
Nature Communications 4, 1523 (2013).

Quantum Phases of Quadrupolar Fermi Gases in Optical Lattices,
S. G. Bhongale, L. Mathey, Erhai Zhao, S. F. Yelin, and Mikhail Lemeshko,
Phys. Rev. Lett. 110, 155301 (2013).

Unconventional spin-density waves in dipolar Fermi gases,
S. G. Bhongale, L. Mathey, Shan-Wen Tsai, Charles W. Clark, and Erhai Zhao,
Phys. Rev. A 87, 043604 (2013).

Current-phase relation for Josephson effect through helical metal,
Christopher T. Olund and Erhai Zhao,
Phys. Rev. B 86, 214515 (2012).

Nearly flat Andreev bound states in superconductor-topological insulator hybrid structures,
Mahmoud Lababidi and Erhai Zhao,
Phys. Rev. B 86, 161108 (2012).

Bond Order Solid of Two-Dimensional Dipolar Fermions,
S. G. Bhongale, L. Mathey, Shan-Wen Tsai, Charles W. Clark, and Erhai Zhao,
Phys. Rev. Lett. 108, 145301 (2012).

Chern numbers hiding in time-of-flight images,
Erhai Zhao, Noah Bray-Ali, Carl J. Williams, I. B. Spielman, and Indubala I. Satija,
Phys. Rev. A 84, 063629 (2011).

Orbital order of spinless fermions near an optical Feshbach resonance,
Philipp Hauke, [Erhai Zhao](#), Krittika Goyal, Ivan H. Deutsch, W. Vincent Liu, and Maciej Lewenstein,
Phys. Rev. A 84, 051603(R) (2011).

Effective action approach to the p-band Mott insulator and superfluid transition,
Xiaopeng Li, [Erhai Zhao](#), and W. Vincent Liu,
Phys. Rev. A 83, 063626 (2011).

Microscopic simulation of superconductor/topological insulator proximity structures,
Mahmoud Lababidi and [Erhai Zhao](#),
Phys. Rev. B 83, 184511 (2011).

Mott scattering at the interface between a metal and a topological insulator,
[Erhai Zhao](#), Chun Zhang, and Mahmoud Lababidi,
Phys. Rev. B 82, 205331 (2010).

Liquid crystal phases of ultracold dipolar fermions on a lattice,
Chungwei Lin, [Erhai Zhao](#), and W. Vincent Liu,
Phys. Rev. B 81, 045115 (2010).

Topological Phases of Dipolar Particles in Elongated Wannier Orbitals,
Kai Sun, [Erhai Zhao](#), and W. Vincent Liu,
Phys. Rev. Lett. 104, 165303 (2010).

An effective field theory for one-dimensional polarized Fermi gases,
[Erhai Zhao](#) and W. Vincent Liu,
J. Low Temp. Phys. 158, 36 (2010).

Modulated pair condensate of p-orbital ultracold fermions,
Zixu Zhang, Hsiang-Hsuan Hung, Chiu Man Ho, [Erhai Zhao](#), and W. Vincent Liu,
Phys. Rev. A 82, 033610 (2010).

Differential conductance anomaly in superconducting quantum point contacts,
Argo Nurbawono, Yuan Ping Feng, [Erhai Zhao](#), and Chun Zhang,
Phys. Rev. B 80, 184516 (2009).

Analytic Thermodynamics and Thermometry of Gaudin-Yang Fermi Gases,
[Erhai Zhao](#), Xi-Wen Guan, W. Vincent Liu, M. T. Batchelor, Masaki Oshikawa,
Phys. Rev. Lett. 103, 140404 (2009).

Theory of quasi-one-dimensional imbalanced Fermi gases,
[Erhai Zhao](#) and W. Vincent Liu,
Phys. Rev. A 78, 063605 (2008).

Orbital Order in Mott Insulators of Spinless p-Band Fermions,
Erhai Zhao and W. Vincent Liu,
Phys. Rev. Lett. 100, 160403 (2008).

Theory of nonequilibrium spin transport and spin transfer torque in superconducting-ferromagnetic nanostructures,
Erhai Zhao and J. A. Sauls,
Phys. Rev. B 78, 174511 (2008).

Temperature scaling of Fermi arcs in the normal state of the underdoped cuprate superconductors,
Erhai Zhao and Arun Paramekanti,
Physica B: Condensed Matter 403, 1104 (2008).

Dynamics of Spin Transport in Voltage-Biased Josephson Junctions,
Erhai Zhao and J. A. Sauls,
Phys. Rev. Lett. 98, 206601 (2007).

Self-consistent slave rotor mean field theory for strongly correlated systems,
Erhai Zhao and Arun Paramekanti,
Phys. Rev. B 76, 195101 (2007).

Temperature dependent Fermi arcs in the normal state of the underdoped cuprate superconductors,
Arun Paramekanti and Erhai Zhao,
Phys. Rev. B 75, 140507 (2007).

BCS-BEC Crossover on the Two-Dimensional Honeycomb Lattice,
Erhai Zhao and Arun Paramekanti,
Phys. Rev. Lett. 97, 230404 (2006).

Excitations in Correlated Superfluids near a Continuous Transition into a Supersolid,
Erhai Zhao and Arun Paramekanti,
Phys. Rev. Lett. 96, 105303 (2006).

Nonequilibrium superconductivity near spin active interfaces,
Erhai Zhao, Tomas Lofwander and J. A. Sauls,
Phys. Rev. B 70, 134510 (2004).

Heat transport through Josephson point contacts,
Erhai Zhao, Tomas Lofwander and J. A. Sauls,
Phys. Rev. B 69, 134503 (2004).

Phase Modulated Thermal Conductance of Josephson Weak Links,
Erhai Zhao, Tomas Lofwander and J. A. Sauls,
Phys. Rev. Lett. 91, 077003 (2003).

Preprint

Cosine Edge Mode in a Periodically Driven Quantum System
Indubala I. Satija, [Erhai Zhao](#), arXiv:1609.02807

Weyl nodes in periodic structures of superconductors and spin active materials
Ahmet Keles, [Erhai Zhao](#), arXiv:1506.05166, accepted by Philosophical Transactions A.

Book Chapter

Topological Insulators with Ultracold Atoms,
Indubala I. Satija and [Erhai Zhao](#),
Chapter 12, *New Trends in Atomic and Molecular Physics*, edited by M. Mohan,
Springer Series on Atomic, Optical, and Plasma Physics Vol. 76, 201 (2013).

Invited Talks at Conferences and Workshops

Topological superconductivity from folding and kicking,
Workshop *Spin-orbit-coupled quantum gases*, Kavli Institute of Theoretical Physics,
Beijing, China, Aug. 16, 2016.

A quantum spin model on the honeycomb lattice,
Nordic Institute for Theoretical Physics, Stockholm, Sweden. June 13, 2016.

Edge modes in periodically driven quantum Hall insulators and p-wave
superconductors,
Workshop *Emergence in driven solid-state and cold-atom systems*, Institute of Laser
Physics, University of Hamburg, Sept. 2015

Competing phases in dipolar quantum gas,
Frontiers in Quantum Simulation with Cold Atoms,
Institute of Nuclear Theory, University of Washington, May 2015

Andreev states in superconductor / topological insulator hybrid structures,
Emergence of new exotic states at interfaces with superconductors,
The Royal Society Theo Murphy International Scientific Meeting,
Buckinghamshire, UK, Mar. 2014.

Bond order of dipolar fermions on an optical lattice,
Fundamental Science and Applications of Ultra-cold Polar Molecules,
Kavli Institute of Theoretical Physics, UC Santa Barbara, Feb. 2013.

Interplay of ferromagnetism and superconductivity at nano-scale,
International Conference of Young Researchers on Advanced Materials,
Materials Research Society of Singapore, Singapore, Jul. 2012.

Ultracold Fermi gases in one and quasi-one dimension,
Frontiers of Ultracold Atoms and Molecules,
Kavli Institute of Theoretical Physics, UC Santa Barbara, Oct. 2011.

Spin-transport and spin-transfer torque in SF nanostructures,
Invited session, *Charge and Spin Transport in Josephson and Proximity Devices*,
American Physical Society March Meeting, Portland, Mar. 2010.

Building a crystalline superfluid one tube at a time,
Condensed Matter Physics of Cold Atoms,
Kavli Institute of Theoretical Physics China, Beijing, Oct. 2009.

Orbital physics in the ultracold,
Condensed Matter Physics of Cold Atoms,
Kavli Institute of Theoretical Physics China, Beijing, Oct. 2009.

Colloquia and Seminar Talks

Superfluidity: from a helium droplet to the interior of neutron stars,
Osher Lifelong Learning Institute, George Mason University, May 2014.

Quantum matter at extreme cold,
Physics Colloquium, College of William and Mary, Apr. 2014.

How to engineer a Weyl semimetal,
Center for Quantum Science, GMU, Oct. 2013.

Recent progress on ultracold dipolar gases,
QiBEC Seminar, Quantum Measurement Division, National Institute of Standards and
Technology, Jun. 2012.

“Proximity effect at the superconductor-topological insulator interface,
Condensed Matter Seminar, Northwestern University, Jan. 2012.

Heterostructures of topological materials: simulating the interface,
Colloquium, Computational Materials Science Center, GMU, Sept. 2010.

Spin flip at the interface between a metal and a topological insulator,
QiBEC Seminar, Quantum Measurement Division, National Institute of Standards and
Technology, Jul. 2010.

One-dimensional Fermi gas with spin imbalance,
Seminar, Institute for Advanced Study, Tsinghua University, Beijing, Oct. 2009.

TEACHING

Courses Taught

Undergraduate level:

Physics 160, University Physics I (Mechanics)

Physics 263: University Physics III lab

Physics 301: Analytical Methods of Physics

Physics 308: Modern Physics with Applications

Graduate level:

Physics 684, Quantum Mechanics I

Physics 685, Classical Electrodynamics I

Physics 785: Classical Electrodynamics II

Physics 703: Seminar in Physics

PhD Students Supervised

(1) Mahmoud Lababidi, graduated in July 2013.

Thesis: *Theory of superconductor-topological insulator heterostructures*.

Published one paper in Physical Review Letters, three in Physical Review B.

Presented research results at the APS March Meeting 2013, 2012, and International Conference on Low Temperature Physics 2011.

(2) Jeff Jaso, current PhD student (with Dr. M. Stiles, NIST).

Postdocs Supervised

(1) Satyan Bhongale (PhD, University of Colorado, Boulder), 2010-2013.

Published two papers in Physical Review Letters and one in Physical Review A.

(2) Zhenyu Zhou (PhD, Washington University, St. Louis), Aug. 2013-2015.

Published one paper in Physical Review Letters and one in Physical Review B.

(3) Ahmet Keles (PhD, University of Washington, Seattle), Aug. 2014-present.

Undergraduates Supervised

(1) Chris Olund, research associate in summer of 2011 and 2012.

Published one paper in Physical Review B.

(2) Jaafar Ansari, Senior Research (Phys 408), Fall 2014.

SERVICES

Conference Organized

Co-organizer (with P. Nikolic and I. Satija), Symposium on Frontiers of Quantum Matter, George Mason University, June 2012.

<http://physics.gmu.edu/~pnikolic/symposium-2012/>

Sessions Chaired in International Conferences

Chair of Session B4: Cold Atoms on Higher Orbital Bands, APS March Meeting, 2013

Chair of Session MM2: Magnetic Nanostructures and Low Dimensional Magnetism, International Conference of Young Researchers on Advanced Materials, Singapore, 2012.

Chair of Session J: Ultra-Cold Atoms, QFS 2009, International Symposium on Quantum Fluids and Solids, 2009.

Grant Reviewer for

National Science Foundation

- Division of Materials Research
- Division of Physics
- Division of Mathematical Sciences

Department of Energy (Theoretical Condensed Matter Physics)

Journal Referee

Journal of Physics A: Mathematical and Theoretical

Journal of Physics: Condensed Matter

Nature Physics

Nature Communications

New Journal of Physics

Physical Review A

Physical Review B

Physical Review Letters

Philosophical Transactions A

Other Affiliations

Guest researcher, National Institute of Standards and Technology, Quantum Measurement Division, 2009-2014.

Member, Center for Quantum Science, George Mason University.

Member, Computational Materials Science Center, George Mason University.

Departmental Committees

- (1) Physics PhD Qualifying Exam Committee.
Member (2010-present).
Committee Chair (Jan. 2012-Sept. 2014).
- (2) Member, Search Committee for Assistant/Associate Professor in Experimental Condensed Matter Physics (SPACS, 2014).
- (3) Co-organizer, SPACS Colloquia, Spring 2013, Fall 2014
- (4) Co-organizer, SPACS Colloquia, Fall 2014.