Caroline S. Gorham, Ph.D.

☎+1 (703) 901-1179 ◇ ✉ gorhamcs@ornl.gov ◇ Oak Ridge, TN 37830
Google Scholar ◇ LinkedIn ◇ ResearchGate ◇ ORCID iD ◇ Personal Site

OVERVIEW

I am a forward-thinking materials scientist (and mechanical engineer) with extensive multi-disciplinary academic research experience in condensed matter physics and heat transfer. I seek complex problems, learn quickly, and thrive on delivering novel solutions. Much of my research to date has focused on ordering field theory approaches to solidification, making use of higher-dimensional complex numbers, and thermal transport properties.

EDUCATION

Carnegie Mellon University **2015-2018**
Ph.D. in Materials Science and Engineering Pittsburgh, PA
Advisor: David E. Laughlin
Thesis: On the formation of crystalline and non-crystalline solid states and their thermal transport properties: A topological perspective via a quaternion orientational order parameter

Carnegie Mellon University **2013-2015**
M.S. in Mechanical Engineering Pittsburgh, PA
Advisor: Alan J. H. McGaughey
Thesis: Thermal transport in buckminsterfullerene molecular solids at and above room temperature

King's College London **2007-2010**
B.Eng. in Mechanical Engineering (1^{st} Class Honours) London, UK

PROFESSIONAL & RESEARCH EXPERIENCE

Postdoctoral Research Associate Oak Ridge, TN
Oak Ridge National Laboratory **02/2020–Present**

- Characterizing topological points in phonon dispersions, via computation of Berry curvatures
- Interrogation of the phenomenological Ginzburg-Landau equations to explore magnetic vortex dynamics in superconductors
- Assessed the viability of read-out mechanisms for topological qubit devices to reliably measure the quantum state of devices

Postdoctoral Research Associate Pittsburgh, PA
Carnegie Mellon University **August 2018 - January 2020**

- Considered generalizations of quantum Hall effects (QHE), from 2D to 4D using quaternion numbers, to better understand frustrated crystalline ground states in the vicinity of a ground state phase transition
- Proposed a basis for interpreting orientational entropy in topologically close-packed (TCP) and glassy solids, in the vicinity of an "ideal glass transition"

Graduate Research Assistant Pittsburgh, PA
Carnegie Mellon University **August 2015 - August 2018**

- Developed a topological framework for crystallization and glass transitions, and their structures, using four-dimensional quaternion orientational order parameters.

- Performed Monte-Carlo simulations of 4D/3D quaternionic condensed matter, which provided evidence for the existence of a topological-ordering transition of defects.
- Anticipated a solidification phase diagram, in the vicinity of a crystalline-to-glass transition, by considering Heisenberg duality characteristics inherent in quaternion order parameters.
- Enabled a fresh perspective on the "ideal glass transition," and the thermal conductivity behavior of crystalline and glassy solid states, by employing a quaternion orientational order parameter.

Visiting Technologist Golden, CO
National Renewable Energy Laboratory **Summer 2015**

- Used python tools to assist in the determination of dynamical properties of the motion of highest occupied molecular orbitals of straight and kinked polymer molecules.
- Performed linear analysis to correlate the frequency dependence of hole conduction in conjugated polymers, for improved organic photovoltaic material design

Visiting Technologist Cleveland, OH
NASA Glenn: Photovoltaic Technologies Division **Summer 2014**

- Developed a Monte-Carlo simulation tool-kit to study the formation of 2D glasses, via a quenched annealing method from undercooled liquids, with cooling rate as the control variable. Annealing processes were simulated using bond-switching, and creation/annihilation of 5- and 7-fold ($\pm$) disclination points were monitored.
- Interrogated vibrational mode properties of C_{60} molecules for improved photovoltaic material design

Graduate Research Assistant Charlottesville, VA
University of Virginia **May 2012 - January 2013**

- Performed optical thermometry-based experiments to measure the thermal conductivity, thermal boundary conductance and sound speed in a wide array of bulk materials and nanosystems
- Produced two first author publications, and was awarded the NASA Space Technology Graduate Research Fellowship (2013).

Systems Engineer I Aurora, CO
Raytheon Company (IIS) **October 2010- October 2011**

- Produced test procedures to ensure high-value functionality of ground control systems
- Integrated system-level components for the net-centric, next-generation, operational ground control system (GPS-OCX)

SKILLS & CERTIFICATIONS

Tools and Software	python, MATLAB, FORTRAN, LaTeX
Certifications	Mechanical Engineering, EIT (2011)

AWARDS

2018	Best Doctoral Thesis in Dept. of Materials Science (Paxton Award)
2013-2017	NASA Space Technology Research Fellowship
2013	NSF Graduate Research Fellowship (Honorable Mention)

PROFESSIONAL SOCIETIES

- MRS (Materials Research Society) 2012–Present
- SWE (Society of Women Engineers) 2013–Present
- APS (American Physical Society) 2014–Present
- PQI (Pittsburgh Quantum Institute) 2018–Present

SELECTED PUBLICATIONS

1. **C.S. Gorham** and D. E. Laughlin, Crystallization in Three-Dimensions: Defect-Driven Topological Ordering and the Role of Geometrical Frustration, *Physical Review B*. (2019)
   DOI: https://doi.org/10.1103/PhysRevB.99.144106
2. **C.S. Gorham** and D. E. Laughlin, Topological Description of the Solidification of Undercooled Fluids and the Temperature Dependence of the Thermal Conductivity of Crystalline and Glassy Solids Above Approximately 50 K, *Journal of Physics: Condensed Matter*. (2019)
   DOI: https://doi.org/10.1088/1361-648X/aaf8d2
3. **C.S. Gorham** and D. E. Laughlin, SU(2) Orientational Ordering in Restricted Dimensions: Evidence for a Berezinskii-Kosterlitz-Thouless Transition of Topological Point Defects in Four Dimensions, *Journal of Physics Communications*. (2018)
   DOI: https://doi.org/10.1088/2399-6528/aace2a/meta
4. R. Cheaito, **C.S. Gorham**, A. Misra, K. Hattar and P. E. Hopkins, Thermal Conductivity Measurements via Time-Domain Thermoreflectance for the Characterization of Radiation Induced Damage, *Journal of Materials Research*. (2015)
   DOI: https://doi.org/10.1557/jmr.2015.11
5. **C. S. Gorham**, K. Hattar, R. Cheaito, J. C. Duda, *et al*, Ion Irradiation of the Native Oxide/Silicon Surface Increases the Thermal Boundary Conductance Across Aluminum/Silicon Interfaces, *Physical Review B*. (2014)
   DOI: https://doi.org/10.1103/PhysRevB.90.024301
6. **C. S. Gorham**, J. T. Gaskins, G. N. Parsons, M. D. Losego and P. E. Hopkins, Density Dependence of the Room Temperature Thermal Conductivity of Atomic Layer Deposition-Grown Amorphous Alumina (Al_2O_3), *Applied Physics Letters*. (2014)
   DOI: https://doi.org/10.1063/1.4885415
7. B. M. Foley, **C. S. Gorham**, J. C. Duda, R. Cheaito, C. J. Szwejkowski, *et al*, Thermal Conductivity of Water Insoluble Protein Films: Anharmonic Interactions of Vibrations in a Fractal Structure, *Journal of Physical Chemistry Letters*. (2014)
   DOI: https://doi.org/10.1021/jz500174x

ARXIV PREPRINTS

1. **C. S. Gorham** and D. E. Laughlin, Quantized Hall Effect Phenomena and Topological Order in 4D Josephson Junction Arrays in the Vicinity of a Quantum Phase Transition, (2019)
   arXiv:1903.11945
2. **C. S. Gorham** and D. E. Laughlin, Solidification of Icosahedral Quasicrystals: Viewpoint Based on a Quaternion Orientational Order Parameter and the Formation of the E8 Lattice, (2019)
   arXiv:1905.12165
3. **C. S. Gorham** and D. E. Laughlin, On the Formation of Solid States Beyond Perfect Crystals: Quasicrystals, Geometrically-Frustrated Crystals and Glasses, (2019)
   arXiv:1907.08839

CONFERENCE PRESENTATIONS

ORAL

1. **C. S. Gorham**, "Topological Order in Condensed Quaternionic Matter: From Dual Superfluids to Glassy Solids." American Ceramics Society, 9 August 2020, Virtual Glass Symposium.
2. **C. S. Gorham**, "Topological Order in Complex and Quaternionic Condensed Matter: From Superfluids to the Solid State." Oak Ridge Postdoc Association Research Symposium, July 2020, Oak Ridge, TN.
3. **C. S. Gorham**, "The Kauzmann Entropy Paradox and the "Ideal Glass Transition" Viewed as a Self-Dual Critical Point at a 4D Crystal/Glass Phase Transition." MRS, Dec 2019, Boston, MA.
4. **C. S. Gorham**, "Importance of Quaternions & Heisenberg Uncertainty in Understanding the Structure and Thermal Conductivity of Crystals and Glasses." International Thermal Conductivity Conference, June 2019, Wilmington, DE.
5. **C. S. Gorham**, "4D Quaternion Numbers, Topological Order & Solidification: Inverse Thermal Conductivity of Crystal and Glasses Above Approx. 50 K." MRS, April 2019, Phoenix, AZ.
6. **C. S. Gorham**, "Thermal Transport in Buckminsterfullerene Molecular Solids At and Above Room Temperature." APS, March 2015, San Antonio, TX.

Invited

1. **C. S. Gorham**, "Importance of Quaternions, Topological-Order and Heisenberg Uncertainty in Understanding Structure and Thermal Conductivity of Glass." Washington St. Louis Physics Dept. (Prof. Zohar Nussinov), December 2019, St. Louis, MO.
2. **C. S. Gorham**, "Importance of Lie Algebras, Dimensions & Topological Ordering: Understanding Structure and Thermal Conductivity of Glasses." Harvard: Condensed Matter Physics Seminar (Prof. David Nelson), January 2019, Boston, MA.
3. **C. S. Gorham**, "What Hopf Fibrations Can Tell Us About Crystallization and Glass Formation." Quantum Gravity Research Group, March 2019, Los Angeles, CA.

Upcoming

1. **C. S. Gorham**, "Generalizations of Topological-Order Beyond U(1): Novel Perspectives on Frustrated Crystals and Inhomogeneous Glassy Solids." APS, March 2021, Nashville, TN.

POSTER

1. **C. S. Gorham**, "Solidification of Glasses & Thermal Transport Properties: Importance of Topology & Heisenberg Uncertainty Principles." Beg Rohu Summer School: Glasses, Jamming and Slow Dynamics, June 2019, Bretagne, FR.
2. **C. S. Gorham**, "Order and Transport Properties in Glassy Solids: Importance of Topological Defects." APS Q2C, April 2019, Denver, CO.
3. **C. S. Gorham**, "Order and Transport Properties of Glassy Solids: Importance of Topological Defects." KAVLI Institute: Order From Chaos, Dec 2018, Santa Barbara, CA.
4. **C. S. Gorham**, "Thermal Conductivity of Water Insoluble Protein Films: Anharmonic Coupling in a Fractal Structure." American Society of Mechanical Engineers, Nov 2013, San Diego, CA.
5. **C. S. Gorham**, "Effects of Surface Treatments on Thermal Boundary Conductance Across Al/Si Interfaces." MRS, April 2013, San Francisco, CA.

REFERENCES

1. *Ph.D. Supervisor*
   Prof. David E. Laughlin, Carnegie Mellon University, Dept. of Materials Science & Engineering
   ✉: laughlin@cmu.edu ☎: (412) 268-2706

2. *Ph.D. Supervisor*
   Prof. Patrick E. Hopkins, University of Virginia, Dept. of Mechanical & Aerospace Engineering
   ✉: phopkins@virginia.edu ☎(434) 982-6005

3. *Thesis Committee Member*
   Prof. Michael Widom, University of Virginia, Department of Physics
   ✉: widom@cmu.edu ☎: (412) 268-7645