

Lucas Caretta, Ph.D.

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Brown University
Providence, Rhode Island 02912, USA

RESEARCH & TEACHING APPOINTMENTS

Brown University
Assistant Professor
Materials Group
School of Engineering

July 2022 – present

EDUCATION

Massachusetts Institute of Technology (MIT) – School of Engineering

June 2019

Doctor of Philosophy in Materials Science and Engineering

National Science Foundation Graduate Research Fellow

GEM Consortium Fellow

Dissertation Title: *Chiral spin textures and dynamics in multi-sublattice magnetic materials*

Advisor: Professor Geoffrey S.D. Beach

University of Minnesota Twin Cities – College of Science and Engineering

May 2013

Bachelor of Science in Materials Science and Engineering

St. Anthony Village Senior High School – St. Anthony Village, Minnesota

June 2009

RESEARCH

Brown University

July 2022 –
present

School of Engineering – Materials Group

Assistant Professor

- Studying novel quantum material systems for spin-based applications
- Developing novel imaging and electronic characterization techniques to study ferroic thin film materials

University of California, Berkeley

Sept 2019 –
June 2022

Department of Materials Science and Engineering (*Advised by Ramamoorthy Ramesh*)

UC President's Postdoctoral Fellow, Ford Foundation Postdoctoral Fellow

Lawrence Berkeley National Laboratory

Affiliate Researcher

- Lead a team of graduate and undergraduate students studying emergent magnetic and multiferroic interface-driven phenomena using atomic scale synthesis and novel characterization tools
- Developed and engineered new room-temperature magnetoelectric materials
- Studied the static and dynamic control of magnetic excitations

Massachusetts Institute of Technology
Department of and Materials Science and Engineering (Advised by Geoffrey Beach)
NSF Graduate Research Fellow, GEM Consortium Fellow
Dissertation: *Chiral spin textures and dynamics in multi-sublattice magnetic materials*

Sept 2013 –
August 2019

- Investigated quantum interface-driven phenomena in magnetic thin films
- Fabrication and design of novel materials systems and physics for quantum, topological spintronic-based memory
- Discovered and exploited emergent phenomena at metal/oxide and oxide/oxide interfaces for magnetic based data storage and logic
- *World records*: smallest room-temperature magnetic skyrmion, fastest magnetic soliton

University of Minnesota – Department of Chemical Engineering and Materials Science

Dec 2009 –
May 2011

Rheology Laboratory Undergraduate Researcher

- Investigated the rheological effects of actively swimming particles in suspension
- Performed error analysis to determine relative error in rheometers
- Designed and Performed experiments using TA Instrument ARES-G2 and AR-G2 rheometers
- Investigated the effects of narrow gap shearing on materials, including how it affects viscosity, temperature, and material response
- Managed and Assisted in the use of Liquid Nitrogen in the Department complying with Environmental Health and Safety standards

PEER-REVIEWED PUBLICATIONS

Google Scholar Metrics:

Citations: 4106

h-index: 16

i10-index: 19

† indicates most significant publications

1. † Nonvolatile electric-field control of inversion symmetry
L. Caretta, Y.-T. Shao, J. Yu, A.B. Mei, B.F. Grosso, C. Dai, P. Behera, D. Lee, M. McCarter, E. Parsonnet, Harikrishnan K.P., F. Xue, X. Guo, E. Barnard, S. Ganschow, Z. Hong, A. Raja, L.W. Martin, L.Q. Chen, M. Feibig, K. Lai, N.A. Spaldin, D.A. Muller, D.G. Schlom, and R. Ramesh
Nature Materials (2022)
1. † Non-volatile Electric Field Control of Thermal Magnons in the Absence of an Applied Magnetic Field
E. Parsonnet, **L. Caretta**, V. Nagarajan, H. Zhang, H. Taghinejad, P. Behera, X. Huang, P. Kavle, A. Fernandez, D. Nikonov, H. Li, I. Young, J. Analytis, R. Ramesh
Physical Review Letters **129**, 087601 (2022)
2. A room temperature polar magnetic metal
H. Zhang, Y.-T. Shao, R.Chen, X. Chen, S. Susarla, D. Raftrey, J. T. Reichenadter, **L. Caretta**, X. Huang, N. S. Settineri, Z.Chen, J. Zhou, E. Bourret-Courchesne, P. Ercius, J. Yao, P. Fischer, J. B. Neaton, D. A Muller, R. J. Birgeneau, R. Ramesh
Physical Review Materials **6** (4), 044403 (2022)
3. Room-temperature skyrmion lattice in a layered magnet (Fe_{0.5}Co_{0.5})₅GeTe₂

- H. Zhang, D. Raftrey, Y.-T. Chan, Y.-T. Shao, R. Chen, X. Chen, X. Huang, J. T. Reichenadter, K. Dong, S. Susarla, **L. Caretta**, Z. Chen, J. Yao, P. Fischer, J. B. Neaton, W. Wu, D. A. Muller, R. J. Birgeneau, R. Ramesh
Science Advances **8** (12), eabm7103 (2022)
4. Electric field control of chirality
P. Behera, M. A. May, F. Gómez-Ortiz, S. Susarla, S. Das, C. T. Nelson, **L. Caretta**, S.-L. Hsu, M. R. McCarter, B. H. Savitzky, E. S. Barnard, A. Raja, Z. Hong, P. García-Fernandez, S. W. Lovesey, G. van der Laan, P. Ercius, C. Ophus, L. W. Martin, J. Junquera, M. B. Raschke, R. Ramesh
Science Advances **8** (1), eabj8030 (2022)
 5. Strain-Induced Orbital Contributions to Oxygen Electrocatalysis in Transition-Metal Perovskites
A. Fernandez, **L. Caretta**, S. Das, C. Klewe, D. Lou, E. Parsonnet, R. Gao, A. Luo, P. Shafer, L. W. Martin
Advanced Energy Materials **2102175** (2021)
 6. Voltage control of ferrimagnetic order and voltage-assisted writing of ferrimagnetic spin textures
M. Huang, M.U. Hasan, K. Klyukin, D. Zhang, D. Lyu, P. Gargiani, M. Valvidares, S. Sheffels, A. Churikova, F. Büttner, J. Zehner, **L. Caretta**, K.-Y. Lee, J. Chang, J.-P. Wang, K. Leistner, B. Yildiz, & G.S.D. Beach
Nature Nanotechnology **16**, 981–988 (2021)
 7. Application concepts for ultrafast laser-induced skyrmion creation and annihilation
K. Gerlinger, B. Pfau, F. Büttner, M. Schneider, L.-M. Kern, J. Fuchs, D. Engel, C. M. Günther, M. Huang, I. Lemes, **L. Caretta**, A. Churikova, P. Hessing, C. Klose, C. Strüber, C.V.K. Schmising, S. Huang, A. Wittmann, K. Litzius, D. Metternich, R. Battistelli, K. Bagschik, A. Sadovnikov, G.S.D. Beach, S. Eisebitt
Applied Physics Letters **118** (19), 192403 (2021)
 8. Unified Framework for Charge-Spin Interconversion in Spin-Orbit Materials
S. Sayed, S. Hong, X. Huang, **L. Caretta**, A.S. Everhardt, R. Ramesh, S. Salahuddin, & S. Datta
Physical Review Applied **15**, 054004 (2021)
 9. Novel Spin–Orbit Torque Generation at Room Temperature in an All-Oxide Epitaxial $\text{La}_{0.7}\text{Sr}_{0.3}\text{MnO}_3/\text{SrIrO}_3$ System
X. Huang, S. Sayed, J. Mittelstaedt, S. Susarla, S. Karimeddiny, **L. Caretta**, H. Zhang, V. A. Stoica, T. Gosavi, F. Mahfouzi, Q. Sun, P. Ercius, N. Kioussis, S. Salahuddin, D. C. Ralph, R. Ramesh
Advanced Materials **33**, 2008269 (2021)
 10. † Relativistic Kinematics of a Magnetic Soliton
L. Caretta, S.-H. Oh, T. Fakhrul, D.-K. Lee, B.H. Lee, S. K. Kim, C. Ross, K.-J. Lee, & G.S.D. Beach
Science **18**, 1438-1442 (2020)
 11. Observation of fluctuation-mediated picosecond nucleation of a topological phase
F. Büttner, B. Pfau, M. Bottcher, M. Schneider, G. Murcurio, C. M. Gunther, P. Hessing, C. Klose, A. Wittmann, K. Gerlinger, L.-M. Kern, C. Struber, C. von K.-S. J. Fuchs, D. Engel, A. Churikova, S. Huang, D. Suzuki, I. Lemes, M. Huang, **L. Caretta**, D. Weder, J. H. Gaida, M. Moller, T. R. Harvey, S. Zayko, K. Bagschik, R. Carley, L. Mercadier, J. Schlappa, A. Yaroslavtsev, L. L. Guyarder, N. Gerasimova, A. Schertz, C. Deiter, R. Gort, D. Hickin, J. Zhu, M. Turcato, D. Lomidze, F. Erdinger, A. Castoldi, S. Maffessanti, M. Porro, A. Samartsev, J. Sinova, C. Ropers, J. H. Mentink, B. Dupe, G. S. D. Beach, and S. Eisebitt
Nature Materials **20**, 30-37 (2020).
 12. Itinerant ferromagnetism in van der Waals $\text{Fe}_{5-x}\text{GeTe}_2$ crystals above room temperature
H. Zhang, R. Chen, K. Zhai, Xiang Chen, **L. Caretta**, X. Huang, R. V. Chopdekar, J. C., J. Sun, J. Yao, R. Birgeneau, and R. Ramesh
Physical Review B **102**, 064417 (2020).
 13. † Interfacial Dzyaloshinskii-Moriya Interaction Arising from Rare-Earth Orbital Magnetism in Insulating Magnetic Oxides.

L. Caretta, E. Rosenberg, F. Büttner, T. Fakhrul, P. Gargiani, M. Valvidares, P. Reddy, C. Ross, G.S.D. Beach

Nature Communications, 11, 1090 (2020).

14. Thermal nucleation and high-resolution imaging of submicrometer magnetic bubbles in thin thulium iron garnet films with perpendicular anisotropy.
F. Büttner, M. A. Mawass, J. Bauer, E. Rosenberg, **L. Caretta**, C. O. Avci, J. Gräfe, S. Finizio, C. A. F. Vaz, N. Novakovic, M. Weigand, K. Litzius, J. Förster, N. Träger, F. Groß, D. Suzuki, M. Huang, J. Bartell, F. Kronast, J. Raabe, G. Schütz, C. A. Ross, and G. S. D. Beach
Physical Review Materials 4, 011401(R) (2020)
15. † Interface-driven chiral magnetism and current-driven domain walls in insulating magnetic garnets
C. O. Avci, E. Rosenberg, **L. Caretta**, F. Büttner, M. Mann, C. Marcus, D. Bono, C. A. Ross, and G. S. D. Beach
Nature Nanotechnology 14, 561–566 2019
16. † Fast current-driven domain walls and small skyrmions in a compensated ferrimagnet,
L. Caretta*, M. Mann*, F. Büttner*, K. Ueda, B. Pfau, C. M. Günther, P. Helsing, A. Churikova, C. Klose, M. Schneider, D. Engel, C. Marcus, D. Bono, K. Bagschik, S. Eisebitt, and G. S. D. Beach
Nature Nanotechnology 13, 1154–1160 (2018) **(Cover Image)**
17. Current-Induced Skyrmion Generation through Morphological Thermal Transitions in Chiral Ferromagnetic Heterostructures
I. Limesh, K. Litzius, M. Böttcher, P. Bassirian, N. Kerber, D. Heinze, J. Zázvorka, F. Büttner, **L. Caretta**, Mann, M. Weigand, S. Finizio, J. Raabe, M. Im, H. Stoll, G. Schütz, B. Dupé, M. Kläui, and G. S. D. Beach
Advanced Materials 1805461, 1–7 (2018)
18. Field-free deterministic ultrafast creation of magnetic skyrmions by spin-orbit torques
F. Büttner, I. Limesh, M. Schneider, B. Pfau, M. Christian, P. Helsing, J. Geilhufe, **L. Caretta**, D. Engel, B. Krüger, J. Viehhaus, S. Eisebitt, and G.S.D. Beach
Nature Nanotechnology 12, 1040–1044 (2017)
19. † Skyrmion Hall effect revealed by direct time-resolved X-ray microscopy
K. Litzius, I. Limesh, B. Krüger, P. Bassirian, **L. Caretta**, K. Richter, F. Büttner, K. Sato, O.A. Tretiakov, J. Förster, R.M. Reeve, M. Weigand, I. Bykova, H. Stoll, G. Schütz, G.S.D. Beach, and M. Kläui
Nature Physics 13, 170 (2017)
20. † Current-induced switching in a magnetic insulator
C. O. Avci, A. Quindeau, C.-F. Pai, M. Mann, **L. Caretta**, A. S. Tang, M. C. Onbasli, C. A. Ross, and G. S. D. Beach
Nature Materials 16, 309 (2017)
21. † Observation of room-temperature magnetic skyrmions and their current-driven dynamics in ultrathin metallic ferromagnets
S. Woo, K. Litzius, B. Krüger, M.-Y. Im, **L. Caretta**, K. Richter, M. Mann, A. Krone, R. M. Reeve, M. Weigand, P. Agrawal, I. Limesh, M.-A. Mawass, P. Fischer, M. Kläui, and G. S. D. Beach
Nature Materials 15, 501 (2016)
22. Enhanced spin-orbit torques in Pt/Co/Ta heterostructures
S. Woo, M. Mann, A. J. Tan, **L. Caretta**, and G. S. D. Beach,
Applied Physics Letters 105, 212404 (2014)
23. Experimental challenges of shear rheology: how to avoid bad data (Book Chapter)
Ewoldt, R.H., M.T. Johnston, **L. Caretta**, " in: S. Spagnolie (Editor), *Complex Fluids in Biological Systems*, Springer (2015)

Publications submitted, under review, or in press:

1. Harnessing Metastable Switching Events in Polar Vortices
P. Behera, E. Parsonnet, F. Gómez-Ortiz, V. Srikrishna, P. Meisenheimer, S. Susurla, P. Kavle, **L. Caretta**, Y. Wu, Z. Tian, A. Fernandez, L. W. Martin, S. Das, J. Junquera, Z. Hong, R. Ramesh

Under Review, Advanced Materials (2022)

1. All optical motion of chiral domain walls and skyrmion bubbles

L. Caretta, K. Litzius, F. Büttner, J. Bartell, L.-M. Kern, D. Suzuki, P. Reddy, F. Steinbach, B. Pfau, C.V.K. Schmising, S. Eisebitt, G.S.D Beach

Under review (2022)

INDUSTRIAL EXPERIENCE

Exxon Mobil Corporation

May 2012 – Aug. 2012 &

Materials Engineering Intern – ExxonMobil Research and Engineering

May 2013 – Aug. 2013

- Redesigned \$100M+ advanced crude corrosion prediction tool for refinery piping lifetime analysis
- Developed a novel \$250k/yr tool to assess ultrasonic C-scan data for corrosion monitoring in local thin areas
- Designed and implementing advanced metallography techniques and analysis to determine failure mechanisms in chrome-based steels

The Boeing Company

May 2011 – Aug. 2011

Student Intern – 737 Research and Technology

- Supported Boeing Research and Technology in materials processing, design, and manufacturing
- Designed, implemented, and initiated an experimental test plan to optimize materials and designs on over 100,000 Fuel Tank Access Doors currently in service
- Implemented Boeing Lean+ business strategies in order to minimize waste in Material and Processing

SERVICE AND OUTREACH

Society of Hispanic Professional Engineers (SHPE)

Nov 2009 – present

National Graduate Committee Chair

June 2014 – April 2017

Regional Student Representative - Region 6

July 2012 – June 2013

- NILA Virtual Conference Committee 2020
- Pioneered and co-authored seed proposal for 5-year, \$3.5M National Science Foundation Grant (NSF LEVERAGES #1642187)
- Developed curriculum and managed 2015/16 SHPE National Conference Graduate Programs, Academic Programs, and Research Symposium for ~10,000 participants
- Developed and implemented a strategic plan throughout midwest to address critical issues and development
- Represented the interests of all current and future undergraduates (1000+) throughout the Midwestern Region

Other: Volunteer graduate/fellowship application reviewer (500+ applications reviewed), materials science outreach to middle and elementary schools (750-1000 students/yr)

INVITED TALKS & CONFERENCE PRESENTATIONS

• WE-Heraeus-Seminar: Re-thinking Spintronics – Invited Talk	2023
• Brown University Condensed Matter Physics Seminar – Invited Talk	2022
• International Conference on Quantum Materials and Technologies (2022) - Invited Talk	2022
• Asia Pacific Center for Theoretical Physics - Invited Talk	2022
• Trends in Magnetism Conference - Invited Talk	2022
• Northwestern University, Materials Science and Eng. Seminar – Invited Talk	2022
• Carnegie Mellon University, Materials Science and Eng. Seminar – Invited Talk	2022
• Brown University Joint Materials and Solid Mechanics Seminar – Invited Talk	2022
• University of Pennsylvania, Materials Science and Eng. Seminar – Invited Talk	2022
• Georgia Institute of Technology, Materials Science and Eng. Seminar – Invited Talk	2022
• University of Minnesota, Chemical Eng. and Materials Science Seminar – Invited Talk	2022
• Cornell University Special Seminar, Materials Science and Engineering – Invited Talk	2021
• University of Tennessee, Nashville Materials Science Seminar – Invited Talk	2021
• University of California, Santa Barbara Materials Colloquium – Invited Talk	2021
• University of California, Irvine MSE Special Seminar – Invited Talk	2021
• Online Spintronics Seminar, spintalks.org – Invited Talk	2021
• University of California, Santa Cruz ECE Seminar – Invited Talk	2021
• APS March Meeting – Invited Talk	2021
• Hsinchu Oxide Online Forum, Taiwan – Invited Talk	2021
• Joint European Magnetic Symposium – Invited Talk	2020
• Magnetic Materials (MMM) – Invited Talk	2020
• Conference of Ford Fellows	2020
• NEMM Magnetism Seminar – UC, Berkeley – Invited Talk	2020
• Condensed Matter Physics Seminar – UC, Berkeley – Invited Talk	2020
• UC, Berkeley Beyond Moore’s Law Seminar – Invited Talk	2020
• INTERMAG 2020 – Invited Talk (<i>cancelled due to COVID-19</i>)	2020
• LaserLab Europe User Meeting – Invited Talk	2019
• LBNL Molecular Foundry Imaging Facility – Invited Talk	2019
• Physical Electronics Conference	2018
• AVS International Symposium and Exhibition	2015
• APS March Meeting	2015, 2019
• C-SPIN Annual Review	2014,15,16,17,18
• Joint Magnetism and Magnetic Materials (MMM)/InterMag	2016, 2019
• International Colloquium on Magnetic Films and Surfaces - Best Student Presentation	2018
• Joint European Magnetic Symposium	2018
• Joint Magnetism and Magnetic Materials (MMM)/InterMag	2019
• Materials Research Society (MRS) Conference - Graduate Student Gold Award	2019
• nCore Annual Review Meeting	2019

SIGNIFICANT FELLOWSHIPS & SCHOLARSHIPS

• University of California - President’s Postdoctoral Fellowship	2020-2022
• Ford Foundation Postdoctoral Fellowship	2020-2022
• National Science Foundation Graduate Research Fellowship	2013-2018
• GEM Consortium Fellowship	Fall 2013

- MRS Graduate Student Gold Award – Fall Meeting Fall 2018
- Best Student Presentation – International Colloquium on Magnetic Films and Surfaces Fall 2018
- MIT DMSE Lemelson-Vest Award for Student Invention Spring 2018
- Society of Hispanic Professional Engineers Professional Scholarship Fall 2017
- Society of Hispanic Professional Engineers Chevron Scholarship Fall 2016
- University of Minnesota Scholarly Excellence in Equity and Diversity Fall 2012
- ASM International – William & Mary Dyrkacz Scholarship Fall 2012
- Donald Leask Fuller Scholarship – Department of Chemical Engineering and Materials Science Fall 2012
- ASM Minnesota Scholarship Spring 2012
- Charles A. Mann Scholarship – Department of Chemical Engineering and Materials Science Fall 2011
- Minnesota High Tech Association Student Scholarship Fall 2011
- ASM International – Dr. George A Roberts Scholarship Fall 2011
- Exxon Mobil LOFT Fellowship – Hispanic Heritage Foundation Fall 2011
- College of Science and Engineering – ADC Foundation Scholarship Fund Fall 2011
- Minnesota Space Grant Consortium Scholarship Award Dec 2010, Dec 2011
- University of Minnesota Presidential Scholarship Award Sept 2009 - 2012
- University of Minnesota President's Distinguished Student Scholarship Sept 2009 - 2013

ADDITIONAL SKILLS

Clean room fabrication, Optical lithography, Sputter deposition, Pulsed laser deposition, Ion Milling, High-vacuum technology, Magnetic, optical and electrical experimental setup design (MOKE, non-linear optics, Hall effect, fs lasers, waveguides, cryo-systems, bulk magnetometry), time- and spatially-resolved X-ray imaging and spectroscopy (XMCD, STXM, PEEM, X-ray Holography, SAXS), Second Harmonic Generation, Electronics Engineering, Metal and Soft Materials Machining, Welding, Metallography, MATLAB, Python, Google SketchUp, Microsoft Office, OriginLAB, LabVIEW, Visual Basic, HTML (CSS)