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Research Interests

- Quantum sensing: Real-time data analysis and field-deployment
- Alkali metals and noble gases for precision measurements, biomagnetism, and navigation

Positions

- Associate Professor, Joint Appointment, Virginia Tech National Security Institute (VTNSI) and the Bradley Department of Electrical and Computer Engineering, Virginia Tech, Blacksburg, VA; July 2024 –Present
  - Quantum Systems Initiative, Spectrum Dominance Division of VTNSI
  - Research small, low-power atomic magnetometers and hyperpolarized noble gas sensors, with a focus on long-term stability and novel cell fabrication
  - Affiliate Faculty with Virginia Tech Center for Quantum Information Science and Engineering
  - VTNSI Quantum Systems Supervisor, Jan. 2025 - Present
  - VT Faculty Liaison, Sept. 2025 - Present
  - Vice President Phi Beta Kappa Mu of Virginia Honors Society Oct. 2025 - Present
  - Faculty Senate ECE Representative

- Physicist, Twinleaf LLC, Plainsboro, NJ; Jan. 2018-Jan. 2024
  - All relevant projects managed by SRI, in collaboration with the Romalis group at Princeton University
  - DARPA AMBIIENT (Atomic Magnetometer for Biological Imaging In Earth's Native Terrain): first demo of unshielded magnetoencephalography using atomic sensors
  - DARPA QuIVER
  - Design, fabrication, and deployment of precision portable, optically pumped magnetometers

- Postdoctoral Research Associate, Associate Research Scholar, Lecturer, Dept. Guest, Department of Physics, Princeton University, Princeton, NJ; Apr. 2014 –Dec. 2019. PI: Mike Romalis
  - DARPA C-SCAN (Chip-Scale Combinatorial Atomic Navigator): noble-gas comagnetometry for a miniature NMR gyro, first to develop mm-sized ^{3}He-^{129}Xe-^{87}Rb cells with long noble gas coherence times
  - Continued novel vapor cell fabrication research, including anodically bonded optical pumping cells
  - Long-term fundamental efforts include spin-gravity searches under an NSF grant, first to detect *J*-coupling between noble gas nuclei

- Lecturer for general physics using Investigative Science Learning Environment (ISLE)

- Teaching + Research Assistant, Ph.D. Student, and Postdoctoral Research Associate, Department of Physics and Astronomy, University of Utah, Salt Lake City, UT; 2005-2007, 2009-2014.
  Project PIs: Brian Saam, Christoph Boehme, Mikhail Raikh, J. Lupton
  - Researched gaseous, liquid, and solid noble-gas spin relaxation mechanism, studied spin-exchange optical pumping
  - Optical pumping of various alkali metal vapors at wide variety of working magnetic fields, and novel vapor cell fabrication, including specialized coatings
  - Studied organic semiconductors for spintronic devices
  - Mentored undergraduates and high-school students
  - TA and course marshal, maintained WebAssign/BlackBoard for entry-level courses

- Adjunct Professor, Life and Natural Sciences Department, Owens Community College, Toledo, OH; 2009

- Teaching Assistant and Ph.D. Student, Department of Mathematics and Statistics, Bowling Green State University, Bowling Green, OH; 2007-2009

- Electrical Apprentice, L & B Electric, Grand Rapids, OH; 2006-2009

Education

- Ph.D., M.Sc., Physics – The University of Utah, 2005-2007;2009-2013, Salt Lake City, UT USA
  Dissertation Title: *^{129}Xe Relaxation and Rabi Oscillations*. Adviser: Brian Saam

- Ph.D. Program, Applied Mathematics – Bowling Green State University, 2007-2009, Bowling Green, OH USA. Adviser: Tong Sun (Masters All but thesis)

- B.Sc., Mathematics, Physics – Bowling Green State University, 2002-2005**,** Bowling Green, OH USA. Honors Title: *The Multi-Fractal Nature of Dynamical Systems*. Adviser: Haowen Xi

Publications

1. M. E. Limes, J. Smoot, J. Perez, J. Freeman, C. Amano-Dolan, D. Peters, W. Lee, *Probe-enhanced Optical Pumping in Low-Pressure ^{87}Rb Vapor Cells for Free-Precession Scalar Magnetometry.* Physical Review A, **113**, 033102 (2026).

2. M. E. Limes, N. Dural , M. V. Romalis, E. L. Foley, T. W. Kornack, A. Nelson, L. R. Grisham, *Long spin-1/2 coherence times in mm-sized anodically bonded ^{3}He-^{129}Xe-^{87}Rb cells.* Applied Physics Letters, **126**, 134001 (2025).

3. T. Wang, W. Lee, M. V. Romalis, M. E. Limes, E. L. Foley, T. W. Kornack, *Pulsed ^{87}Rb vector magnetometer using a fast rotating field.* Nature Communications **16**, 1374 (2025)

4. M. E. Limes, L. Rathbun, E. L. Foley, T. W. Kornack, Z. Hainsel, A. Braun, *Frequency-dependent amplitude correction to free-precession magnetometers.* IEEE Sensors Letters **9**, 1, 1500404 (2025)

5. V. G. Lucivero, W. Lee, T. W. Kornack, M. E. Limes, E. L. Foley, M. V. Romalis, *Femtotesla nearly quantum-noise-limited gradiometer at Earth-scale fields.* Phys. Rev. Applied *Letter* **18**, L021001 (2022)

6. W. Lee, V. G. Lucivero , M. V. Romalis, M. E. Limes, E. L. Foley, T. W. Kornack, *Heading errors in an all-optical pulsed-pump ^{87}Rb magnetometer in geomagnetic fields.* Phys. Rev. A **103**, 063103 (2021) *Editors' Suggestion*

7. A. Jaufenthaler , T. Kornack, V. Lebedev, M. E. Limes, R. Korber, M. Liebl, D. Baumgarten, *Pulsed optically pumped magnetometers: Addressing dead time and bandwidth for unshielded magnetorelaxometry of magnetic nanoparticles.* Sensors **21**(4), 1212 (2021)

8. M. E. Limes, E. L. Foley, T. W. Kornack, S. Caliga, S. McBride, A. Braun, W. Lee, V. G. Lucivero, M. V. Romalis, *Portable magnetometry for detection of biomagnetism in ambient environments.* Phys. Rev. Applied *Letter* **14**, 011002 (2020) *Editors' Suggestion Portable Sensor Detects Biomagnetic Signals in Noisy Outdoor Environments* by Ian Randall, Physics World

9. M. E. Limes, N. Dural, M. V. Romalis, E. L. Foley, T. W. Kornack, A. Nelson, L. R. Grisham, J. Vaara, *Dipolar and scalar ^{3}He-^{129}Xe frequency shifts in stemless cells*. Phys. Rev. A **100**, 010501 (R) (2019)

10. M. E. Limes, D. Sheng, and M. V. Romalis, *^{3}He-^{129}Xe comagnetometry with ^{87}Rb detection and decoupling*, Phys. Rev. Lett. **120**, 033401 (2018). *Editors' Suggestion, Featured in Physics, Viewpoint*: https://physics.aps.org/articles/v11/5

11. M. E. Limes, Z. L. Ma, E. G. Sorte, and B. Saam, *Robust solid ^{129}Xe longitudinal relaxation times*, Phys. Rev. B **94**, 094309 (2016).

12. D. P. Waters, G. Joshi, M. Kavand, M. E. Limes, H. Malissa, P. L. Burn, J. M. Lupton, and C. Boehme, *The spin-Dicke effect in OLED magnetoresistance*, Nature Physics **11**, 910-914 (2015).

13. K. J. van Schooten, D. L. Baird, M. E. Limes, J. M. Lupton, and C. Boehme, *Probing carrier-pair spin-spin interactions in a conjugated polymer by detuning of electrically detected spin-beating*, Nature Communications **6**, 6688 (2015).

14. E. F. Thenell, M. E. Limes, E. G. Sorte, Z. V. Vardeny, and B. Saam, *Nuclear relaxation measurements in organic semiconducting polymers for application to organic spintronics*, Phys. Rev. B **91**, 045205 (2015).

15. M. E. Limes, J. Wang, W. J. Baker, S.-Y. Lee, B. Saam, and C. Boehme, *Numerical study of spin-dependent transition rates within pairs of dipolar and exchange coupled spins with s=1/2 during magnetic resonant excitation*, Phys. Rev. B **87**, 165204 (2013).

16. R. Glenn, M. E. Limes, B. Saam, C. Boehme, and M. E. Raikh, *Analytical study of spin-dependent transition rates within pairs of dipolar and strongly exchange coupled spins with s=1/2 during magnetic resonant excitation*, Phys. Rev. B. **87**, 165205 (2013).

17. R. Glenn, M. E. Limes, B. Pankovich, B. Saam, and M. E. Raikh, *Magnetic resonance in slowly modulated longitudinal field: Modified shape of the Rabi oscillations*, Phys. Rev. B. **87**, 155128 (2013).

18. L. P. Fulcher, R. C. Scherer, A. Melnykov, V. Gateva, and M. E. Limes, *Negative Coulomb damping, limit cycles, and self-oscillation of the vocal folds*, Am. J. Phys. **74**, 386 (2006).

Patents

1. T. Wang, W. Lee, M. V. Romalis, M. E. Limes, E. L. Foley, T. W. Kornack, *Pulsed Vector Magnetometer Using a Fast Rotating Field* (US20250314721A).

2. W. Lee, M. V. Romalis, V. Lucivero, M. E. Limes, E. L. Foley, T. W. Kornack, *System and Method for Heading Error Correction in a Pulsed 87Rb Magnetometer at Geomagnetic Fields* (US20220221277).

Selected Presentations

- M. E. Limes, B. Talbert, J. Smoot, M. Linville, *Hyperfine resolved Optical Pumping for Precision Magnetometry in Earth-scale fields,* 2026 APS DAMOP Meeting, 06/2026, Providence, RI

- B. Talbert, M. E. Limes, *Light Shifts in Free-precession Alkali Magnetometry in Earth-scale fields,* Poster, 2026 APS DAMOP Meeting, 06/2026, Providence, RI

- M. E. Limes, *Quantum Sensing Primer,* DARPA Service Chief Fellows at VTNSI, 06/2026

- M. E. Limes, *Magnetometry Tutorial*, Invited keynote talk, 2026 Polarization in Noble Gases, 04/2026, Luss, Scotland

- M. E. Limes, *Quantum Sensing for Navigation*, Psaiki and Joerger lab seminar, 04/2026, Blacksburg, VA

- J. Smoot, J. Perez, J. Freeman, C. Amano-Dolan, D. Peters, M. E. Limes, *Probe-enhanced Optical Pumping in Low-Pressure ^{87}Rb Vapor Cells for Free-Precession Scalar Magnetometry*, 2025 Annual Meeting of the APS South-Eastern Section, 10/2025, Harrisonburg, VA

- M. E. Limes, J. Smoot, J. Perez, J. Freeman, *Expanding Low-Frequency Capabilities of Alkali Magnetometers*, National Reconnaissance Office, NRO FIRST 2025, 10/2025, Chantilly, VA

- M. E. Limes, *Compact Opto-atomic Receiver for Detection of VLF and Atmospherics* (CORDOVA), Invited talk, Office of Naval Research Communications Gathering, 08/2025, Arlington, VA

- M. E. Limes, *Spin-based Magnetometers and Gyros at VTNSI*, ECE Graduate Student Seminar, 04/2025, Blacksburg, VA

- M. E. Limes, *Atomic Physics on the Brain*, Colloquium, Fralin Biomedical Institute at VTC, 07/2024, Roanoke, VA Atomic Physics on the Brain - Virginia Tech - Video (vt.edu)

- M. E. Limes, E. L. Foley, T. W. Kornack, S. Caliga, S. McBride, A. Braun, W. Lee, V. G. Lucivero, M. V. Romalis, *A portable ^{87}Rb gradiometer operating in Earth's field*, 2020 APS DAMOP Meeting, 05/2020, Portland, OR (Online)

- M. E. Limes, N. Dural, M. V. Romalis, E. L. Foley, T. W. Kornack, A. Nelson, L. R. Grisham *Dipolar and scalar ^{3}He and ^{129}Xe frequency shifts in mm-sized cells*, 2018 APS DAMOP meeting, 05/2018, Ft. Lauderdale, FL

- M. E. Limes, *Optical Detection of a Nuclear-spin Gyro*, Colloquium Miami University, 02/2017, Oxford, OH

- M. E. Limes, D. Sheng, M. V. Romalis, *A ^{3}He-^{129}Xe co-magnetometer with ^{87}Rb magnetometry*, 2016 APS DAMOP meeting, 05/2016, Providence, RI

- M. E. Limes, D. Sheng, M. V. Romalis, *Progress on a ^{3}He-^{129}Xe co-magnetometer*, 2015 APS DAMOP meeting, 06/2015, Columbus, OH

- M. E. Limes, *^{129}Xe Relaxation and Rabi Oscillations* Pines Lab Seminar, 12/2013, UC Berkeley, CA

- M. E. Limes, Z. L. Ma, and B. Saam, *Altered states of solid xenon*, Poster 2012 DAMOP Meeting, 05/2012, Orange County, CA

- M. E. Limes and B. Saam, *Relaxation of low-field gas-phase ^{129}Xe*, Contributed Talk 2010 APS/Four Corners Meeting, 10/2010, Ogden, UT

Research Supervision

Current Students

- **Graduate Students**
  Brady Talbert (Physics PhD), Oct. 2025 -Present
  Julia Rodrigues (ECE Masters), (Aug. 2026)
  Alexander Buckholder (ECE PhD), (Aug. 2026)

- **Undergraduate Students**
  Max Linville (ECE/Physics), Jan. 2026-Present
  Jeb Smoot (Physics), Sept. 2024-Present

Past Students/Researchers

Advait Guje, (ECE), Jan. 2026-May 2026
Olivia Watt (ECE/Physics), Nov. 2025- May 2026
Umesh Andalari (ECE), Oct. 2025 - May 2026
Sandra Agyapong (ECE), Sept. 2025-May 2026
August Boldt (ECE), Sept. 2025- May 2026
Jeffrey Ramirez-Majano , Sept. 2025 - May 2026
TJ O'Conner (ECE, Physics), Sept. 2025-May 2026
Miles Riley (ECE), Sept. 2025-May 2026
Dhruv Amin (ECE), Sept. 2025-May 2026
Timothy Estrada (ECE, Physics), Sept. 2025 - May 2026
Chris Lin (ECE), Sept. 2025- May 2026
Tamara Corvera (ECE), Sept. 2025-May 2026
Corey Ahl (ECE), Sept. 2025-May 2026
Jake Freeman (ECE), Sept. 2024-May 2026
Jamie Perez (Physics), Sept. 2024-May 2026
Tai Kark (ME), Sept. 2025-Jan.2026
Carolyn Amano Dolan (Physics), Jan. 2025- Oct. 2025 (via PHYS-4316)
Devin Peters (Physics), Jan. 2025- May 2025 (via PHYS-4316)

-Tyler Wells, Adam Dillingham, Marc Nguyen, AJ Dempsey, Andrew Merdes (via ECE 4805 - 4806 - MDE Major Design Experience Client and Subject Matter Expert, Controllers for Portable Quantum Sensing Packages, Fall 2024 - Spring 2025)

PhD Committee Member

- ECE: Photonics
  Ata Shakiri, Advisor: Zin Lin, Spring 2025-
  Arvin Keshvari, Advisor: Zin Lin, Spring 2025-
  Xintong Yang, Advisor, Advisor: Xiaoting Jia, Fall 2025-

Courses

Virginia Tech

ECE 3704 - Continuous and Discrete System Theory, Spring 2025, Spring 2026

Princeton University

PHY102 - General Physics II, Spring 2017

University of Utah

PHYS 2020 - 2021 - General Physics, Fall 2005, Spring 2006, Fall 2006, Spring 2007, Fall 2009, Spring 2010

Owens Community College

AST 101 - Astronomy, Spring 2009

PHY 143 - Applied Industrial Physics, Spring 2009

Bowling Green State University

MATH126 - Business Calculus, Fall 2007, Spring 2008, Fall 2008

Honors

- James Robert and Gretchen Overman Undergraduate Physics Scholarship, 2004
- Phi Beta Kappa Society, Xi of Ohio, 2005
- Kappa Mu Epsilon National Mathematics Honors Society, Ohio Alpha, 2005
- J. Irvin and Norma K. Swigart Outstanding Graduate Student, 2013
- Vice President Phi Beta Kappa Mu of Virginia Honors Society Oct. 2025 - Present

Academic Service

Virginia Tech

- DAMOP Session Chair 2026 *Fundamentals of Quantum Metrology and Control*
- Large Course Community of Practice Spring 2026
- College of Engineering Faculty Liaison FY26
- College of Science Dean's Discovery Fund Review Committee Spring 2025
- Presidential Postdoctoral Fellowship Review Committee Spring 2025
- National Security Institute Seminars Committee, Fall 2024 - Present
- Presidential Postdoctoral Fellowship Review Committee Fall 2024
- Mu of Virginia Phi Beta Kappa Representative, Fall 2024 - Present
- VTNSI Quantum Systems Postdoctoral Scholar Search Committee Fall 2024-Spring 2025

University of Utah

- Department of Physics Graduate Student Association President, 2011-2013
- College of Science, Office of the Dean Curriculum Committee, 2011-2012
-

- **Referee**: *Physical Review A, Physical Review B, Physical Review Letters, Physical Review Applied, Physical Review X, Journal of Applied Physics, IEEE Photonics Technology Letters, Journal of Magnetic Resonance, IEEE Sensors, Optics Express, Chinese Optics Letters, IEEE Transactions on Instrumentation and Measurement, Alexandria Engineering Journal, Nature, Nature Photonics, Nature Physics, IEEE Transactions on Instrumentation & Measurement, Nature Communications Physics, APS Open Science, Advanced Quantum Technologies*