mlimes.com
+1-419-494-5628
limes.mark@gmail.com, mlimes@vt.edu

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
  - Tenure-track 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

- 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

- 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, 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).

2. 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)

3. 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)

4. 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)

5. 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*

6. 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)

7. 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

8. 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)

9. 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

10. 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).

11. 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).

12. 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).

13. 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).

14. 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).

15. 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).

16. 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).

17. 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. 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, *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*, Contributed Talk
  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*, Contributed Talk
  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

Sponsored Research

Magnetometry

- M. E. Limes and T. Kornack, *Hot Optical Thermoimmune Magnetometer*, DARPA Magnetic High Temperature Sensors (MagHITS), ($1M) 2023-2024

Pending

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Research Supervision

Current Students

- Undergraduate Students
  Jake Freeman (ECE), 2024-Present
  Jeb Smoot (Physics), 2024-Present
  Jamie Perez (Physics), 2024-Present
  Carolyn Amano Dolan (Physics), Jan. 2025- Present (via PHYS-4316)
  Devin Peters (Physics), Jan. 2025- Present (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)

Committee Member

- Qualifying Exam, Photonics
  Ata Shakiri, Advisor: Zin Lin, Spring 2025
  Arvin Keshvari, Advisor, Zin Lin, Spring 2025

Courses

Virginia Tech
ECE 3704 - Continuous and Discrete System Theory, Spring 2025

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
- Physics Graduate Student Advisory Council President, 2010
- J. Irvin and Norma K. Swigart Outstanding Graduate Student, 2013

Academic Service

- Referee: *Physical Review B, IEEE Photonics Technology Letters, Journal of Magnetic Resonance, IEEE Sensors, Physical Review Letters, Physical Review Applied, Physical Review A, Optics Express, Chinese Optics Letters, IEEE Transactions on Instrumentation and Measurement, Physical Review X, Alexandria Engineering Journal*

- VT College of Science Dean's Discovery Fund Review Committee Spring 2025
- VT Presidential Postdoctoral Fellowship Review Committee Spring 2025
- VT National Security Institute Seminars Committee, Fall 2024 - Present
- VT Presidential Postdoctoral Fellowship Review Committee Fall 2024
- VT Mu of Virginia Phi Beta Kappa Representative, Fall 2024 - Present
- VTNSI Quantum Systems Postdoctoral Scholar Search Committee Fall 2024-Spring 2025