# Greg A. Riggs


Contact Information

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## Education

**West Virginia University**, Morgantown, WV

**Ph.D., Physics**, December 2024
Dissertation: Experimental Verification and Time-resolved Bispectral Analysis of Nonlinear Coupling in the Toroidicity-induced Alfvén Eigenmode Spectrum
Advisor: *Prof. Mark E. Koepke*

**M.S., Physics**, May 2020
Thesis: Interpretations of Bicoherence in Space & Lab Plasma Dynamics
Advisor: *Prof. Mark E. Koepke*

**B.S., Physics**, August 2017
Capstone: Vibrational Modes of a Square Membrane

## Recognition

Research Trust Fund Seehra Research Award (April 2021, 2024)
Sherwood Fusion Theory Student Poster Award (May 2023)
ITPA EP topical group expert member (March 2024)
Featured Article in *Physics of Plasmas* (April 2024)

## Fellowship

Oleg D. and Valentina P. Jefimenko Physics Fellowship — Fall 2023–Spring 2024

## Work Experience

**Research Fellow**, Dept. of Climate & Space Sciences & Engineering, University of Michigan — Spring 2026–Present
Supervisor: *Prof. Weichao Tu*

- Development of radial electron diffusion coefficients with resolution in equatorial pitch-angle and geomagnetic activity index $K_p$ — *January 2026–Present*
  - Investigating time variation of the pitch-angle dependence of radial electron diffusion coefficients $D_{LL}$ using 3D guiding center simulations.
  - Quantifying the effect of non-axisymmetric geomagnetic fields on wave-particle interaction and energetic electron transport.
  - Incorporating empirical models of wave power to supply self-consistent field perturbations comporting with spacecraft measurements.

**Postdoctoral Researcher**, Dept. of Physics & Astronomy, West Virginia University — Fall 2024–Fall 2025
Supervisor: *Prof. Weichao Tu*

- Quantification of ultra-low frequency (ULF) wave power distribution in the outer radiation belt — *January 2025–January 2026*
  - Developed efficient code to analyze magnetic fluctuations from THEMIS spacecrafts (14-year dataset) and Arase/ERG mission (3.5-year dataset).
  - Inferred ULF wave power dependence on magnetic local time (MLT), magnetic latitude (MLat), radial location ($L$ shell), $K_p$, and frequency. Results show substantial deviations from fundamental mode during times of high activity.
  - Performed 2D regression fitting of ULF power and uncertainty as a quadratic function of MLat and $L$ shell, for three regimes of $K_p$.

**Demo Coordinator**, Dept. of Physics & Astronomy Fall 2024
West Virginia University
Supervisor: *Prof. Paul Miller*

- Managed construction and implementation of approximately three dozen unique demonstrations for introductory physics lectures.
- Supervised application of physics demonstrations in outreach events.

**Research Assistant**, Dept. of Physics & Astronomy Summer 2019–Summer 2024
West Virginia University
Advisor: *Prof. Mark E. Koepke*

- Quantification of nonlinear coupling between toroidicity-induced Alfvén eigenmodes (TAE) in DIII-D tokamak *March 2021–July 2024*
  - Participated in planning and execution of experimental run-day.
  - Characterized nonlinear interactions involving two TAE and low-frequency (∼20kHz) magnetohydrodynamic (MHD) mode via wavelet-based bicoherence analysis of poloidal magnetic fluctuations; uncertainty quantified via statistical method appropriate for nonstationary time series.
  - Evaluated toroidal and poloidal modenumber and radial localization of participating fluctuations using inductive probe array, interferometry, and beam-emission spectroscopy (BES).
  - Conducted global simulations of tokamak with benchmarked gyro-Landau-fluid code (FAR3d) on NERSC Perlmutter supercomputer.
  - Developed open-source, object-oriented packages in MATLAB and Python for polyspectral analysis of scalar and multidimensional data.
  - Conceptualized and implemented novel bispectral analysis which captures time-resolved "signature" of non-vanishing bicoherence.
  - Demonstrated instantaneous difference frequency $\Delta f = f_1 + f_2 - f_3$ locking during three-wave coupling; discovered dozens of nonlinear interactions with sub-millisecond duration.
- Investigation of gradient effects in spectroscopic determination of temperature and density in high-energy density (HED) plasma *June 2019–May 2023*
  - Performed spectroscopic simulations of NaFMgO plasma using collisional-radiative model (PRISMSPECT), some incorporating gradients in space or time. Results compared with data from experiments on the Z-machine at Sandia National Laboratory (SNL).
  - Optimized analysis code to enhance throughput by factor of $\sim 300$.
  - Inferred temperature and density of plasma by comparing line-area ratios and line widths, respectively, of experimental spectral features with output of model.
  - Generalized one-dimensional method of temperature determination to enable statistical assessment of best-fit temperature gradient.

**Lab Assistant**, Dept. of Physics & Astronomy Spring 2018–Fall 2018
West Virginia University
Supervisor: *Prof. Mark E. Koepke*

- Bispectral analysis of archived DIII-D data *February 2018–December 2018*
  - Developed stand-alone application for analysis of bispectral features.
  - Analyzed magnetic fluctuations of ∼100 DIII-D discharges to assess likelihood of nonlinear coupling.

## Teaching Experience

**Instructor**, Dept. of Physics & Astronomy — Summer 2024–Fall 2024
West Virginia University

- Introductory Physics I (PHYS 101) — *August 2024–December 2024*
  - Exhibited proficiency teaching first course in (algebra-based) mechanics.
  - Demonstrated effectiveness in lecturing to large number ($\sim 150$) of students.
  - Performed simple experiments and demonstrations to confirm the consistency of physical laws.
  - Assisted in the development, coordination, and proctoring of exams.
- Introductory Physics II (PHYS 102) — *June 2024–August 2024*
  - Taught first course in electromagnetism to class of 24 undergraduates.
  - Developed and graded homework problems, quizzes, and exams to assess students' mastery of physics concepts and applications.

**Teaching Assistant**, Dept. of Physics & Astronomy — Spring 2019
West Virginia University

- General Physics I (PHYS 111) — *January 2019–May 2019*
  - Served as instructor in advanced introductory physics laboratory.
  - Led simple experiments to enhance intuition and conceptual understanding.
  - Graded weekly quizzes in addition to midterms and final exams.

## Journal Publications

**7** BicAn: An integrated, open-source framework for polyspectral analysis
(2026) *Computer Physics Communications*, 323, 110097
**G. Riggs**, M. Koepke, T. Matheny

**6** Instantaneous difference-frequency locking observed in coupled eigenmodes on the DIII-D tokamak
(2026) *Nuclear Fusion*, 66, 036037
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong

**5** Dependence of ion-cyclotron range of frequencies instabilities on species mix and fast-ion distribution (Part II: Time evolution)
(2025) *Nuclear Fusion*, 65, 116022
W. Heidbrink, G. DeGrandchamp, J. Lestz, K. Thome, S. Vincena, N. Crocker, X. Du, R. Pinsker, **G. Riggs**, S. Tang, M. Van Zeeland

**4** Time-resolved biphase signatures of quadratic nonlinearity observed in coupled Alfvén eigenmodes on the DIII-D tokamak **(Featured Article)**
(2024) *Physics of Plasmas*, 31(4), 042305
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong

**3** Role of simple spatial gradient in reinforcing the accuracy of temperature determination of HED plasma via spectral line-area ratios
(2023) *Atoms*, 11(7), 104
**G. Riggs**, M. Koepke, T. Lane, T. Steinberger, P. Kozlowski, I. Golovkin

**2** Establishing an isoelectronic line ratio temperature diagnostic for soft X-ray absorption spectroscopy
(2022) *High Energy Density Physics*, 45, 101019
T. Lane, M. Koepke, P. Kozlowski, **G. Riggs**, T. Steinberger, I. Golovkin

**1** Bispectral analysis of broadband turbulence and geodesic acoustic modes in the T-10 tokamak
(2021) *Journal of Plasma Physics*, 87(3), 885870301
**G. Riggs**, S. Nogami, M. Koepke, A. Melnikov, L. Eliseev, S. Lysenko, P. Khabanov, M. Drabinskij, N. Kharchev, A. Kozachek, M. Ufimtsev and HIBP Team

## Manuscripts Submitted/ In Preparation

**2** Parameterization of the Latitudinal Dependence of ULF Waves in the Magnetosphere via Long-term Statistical Observations
(2026) Submitted to *Journal of Geophysical Research: Space Physics*
**G. Riggs**, W. Tu, T. Sarris

**1** Formal power series for infinite exponential of analytic function
(2026) Submitted to *The American Mathematical Monthly*
**G. Riggs**

## Invited Talks

**1** Wave-wave coupling of fast-ion driven instabilities in the DIII-D tokamak
*West Virginia University* (Nov. 5, 2025)

## Oral Presentations

**9** Understanding off-equatorial radiation belt electron radial diffusion via empirical modeling and single particle tracing
*International Space Science Institute Topical Group Meeting* (Mar. 17, 2026)
**G. Riggs**, W. Tu, T. Sarris

**8** BicAn: An integrated, open-source framework for polyspectral analysis
*67th Annual Meeting of the APS Division of Plasma Physics* (Nov. 20, 2025)
**G. Riggs**, M. Koepke

**7** Statistical ULF wave latitude distribution: A key to understanding off-equatorial radiation belt electron radial diffusion
*GEM/CEDAR Workshop* (Jun. 25, 2025)
**G. Riggs**, W. Tu, T. Sarris

**6** Instantaneous difference-frequency locking observed in coupled eigenmodes on the DIII-D tokamak
*ITPA EP Topical Group Meeting* (Mar. 21, 2025)
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong, Y. Ghai

**5** Instantaneous difference-frequency locking observed in coupled eigenmodes on the DIII-D tokamak
*DIII-D Energetic Particle Group* (Mar. 5, 2025)
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong, Y. Ghai

**4** Time-resolved bispectral signatures of TAE mode-mode coupling observed in the DIII-D tokamak
*ITPA EP Topical Group Meeting* (Oct. 2, 2024)
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong, Y. Ghai

**3** Time-resolved biphase signatures of quadratic nonlinearity observed in coupled eigenmodes on the DIII-D tokamak
*KINETIC Center Workshop* (Aug. 22, 2024)
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong, Y. Ghai

**2** Time-resolved biphase signatures of quadratic nonlinearity observed in coupled eigenmodes on the DIII-D tokamak
*Princeton Plasma Physics Laboratory Energetic Particle Seminars* (Nov. 29, 2023)
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong, Y. Ghai

**1** Time-resolved biphase signatures of quadratic nonlinearity observed in coupled eigenmodes on the DIII-D tokamak
*DIII-D Energetic Particle Group* (Oct. 11, 2023)
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong

## Conference Posters

**14** Statistical ULF wave latitude distribution: A key to understanding off-equatorial radiation belt electron radial diffusion
*American Geophysical Union (AGU) Annual Meeting* (December 2025)
**G. Riggs**, W. Tu, T. Sarris

**13** Estimating the radial diffusion coefficient of off-equatorial relativistic electrons in the radiation belts due to geomagnetic latitude-dependent ULF waves
*American Geophysical Union (AGU) Annual Meeting* (December 2025)
T. Sarris, X. Li, H. Zhao, W. Tu, **G. Riggs**, S. Tourgaidis, K. Papadakis, W. Liu, L. Yan

**12** Comprehensive analysis of beam-driven ion cyclotron range instabilities in mixed species DIII-D plasmas
*67th Annual Meeting of the APS Division of Plasma Physics* (November 2025)
J. Lestz, W. Heidbrink, N. Crocker, G. DeGrandchamp, K. Thome, S. Tong, S. Vincena, K. Barada, X. Du, W. Peebles, R. Pinsker, T. Rhodes, **G. Riggs**, S. Tang, M. Van Zeeland, L. Zeng

**11** Statistical ULF wave latitude distribution: A key to understanding off-equatorial radiation belt electron radial diffusion
*GEM/CEDAR Workshop* (June 2025)
**G. Riggs**, W. Tu, T. Sarris

**10** Time-resolved biphase signatures of quadratic nonlinearity observed in coupled eigenmodes on the DIII-D tokamak
*65th Annual Meeting of the APS Division of Plasma Physics* (November 2023)
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong

**9** Time-resolved biphase signatures of quadratic nonlinearity observed in coupled eigenmodes on the DIII-D tokamak
*Sherwood Fusion Theory Conference* (May 2023)
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong

**8** Preliminary identification and characterization of nonlinear wave-wave, wave-beam, and wave-particle interactions in beam-driven tokamak plasma
*64th Annual Meeting of the APS Division of Plasma Physics* (November 2022)
**G. Riggs**, M. Koepke, W. Heidbrink, M. Van Zeeland, D. Spong

**7** TJ-II observations of nonlinear wave-wave coupling in play during Alfven-Eigenmode / Turbulence / Zonal-Flow interactions
*64th Annual Meeting of the APS Division of Plasma Physics* (November 2022)
M. Koepke, F. Papousek, M. Ochando, C. Hidalgo, B. van Milligen, **G. Riggs**

**6** Constraining magnitudes of nonzero temperature and density gradients using absorption spectra of radiatively heated target-foil plasma
*Stewardship Science Academic Programs Symposium* (February 2022)
**G. Riggs**, T. Lane, P. Kozlowski, M. Koepke

**5** Constraining magnitudes of nonzero temperature and density gradients using absorption spectra of radiatively heated target-foil plasma
*63rd Annual Meeting of the APS Division of Plasma Physics* (October 2021)
**G. Riggs**, M. Koepke, T. Lane, P. Kozlowski

**4** Spectroscopic method to obtain n, T applied to soft x-ray absorption spectra in radiatively heated Z-pinch plasmas
*Stewardship Science Academic Programs Symposium* (February 2021)
**G. Riggs**, T. Lane, P. Kozlowski, M. Koepke

**3** Bispectral analysis of broadband and quasi-coherent oscillations (geodesic-acoustic modes) to interpret wave-wave interactions in the T-10 Tokamak
*61st Annual Meeting of the APS Division of Plasma Physics* (November 2019)
M. Koepke, S. Nogami, **G. Riggs**, A. Melnikov, L. Eliseev, S. Lysenko, P. Khabanov, M. Drabinskij, N. Kharchev, A. Kozachek, M. Ufimtsev

**2** Interpretation of bi-coherence in space and lab plasma-wave dynamics
*60th Annual Meeting of the APS Division of Plasma Physics* (November 2018)
**G. Riggs**, S. Nogami, M. Koepke, N. Crocker, G. Howes, S. Savin, V. Budaev, L. Zelenyi

**1** Alfvén Eigenmode (AE) interactions in Tokamaks: DIII-D Frontier Science Experiments connecting the physics of nonlinear waves and processes in space plasmas
*60th Annual Meeting of the APS Division of Plasma Physics* (November 2018)
M. Koepke, S. Nogami, **G. Riggs**, G. Howes, N. Crocker, T. Carter, W. Heidbrink, M. Van Zeeland

## Skills

**Matlab and Python**
Substantial experience (Matlab: 14 years, Python: 9 years) designing, developing, debugging, benchmarking, and deploying analysis routines, visualizations, GUIs, and games. Highlights include simulation of field from curvilinear antenna, 2.5D Landau-fluid MHD simulations, real-time bispectral analyzer, and open-source platforms for polyspectral analysis (PyBic/BicAn).

**C/C++**
Approximately 8 years experience enhancing throughput and efficiency of analysis routines originally written in Matlab/Octave or Python. Used extensively for back-end of Arduino projects (see below) and hobbyist game design.

**IDL**
Developed numerous routines for acquisition, analysis, and output of DIII-D tokamak data over 7 year period. Familiar with Spedas package for interacting with data from multiple spacecraft, *e.g.*, THEMIS, Arase, or Cluster.

**Shell scripting**
Practiced with Unix systems and command-line interfaces, with preference for Bash. Experienced with connecting diverse workflows in multiple languages. Source code management and version control of dozens of routines performed with Git.

**Electronics**
Familiarity with printed circuit board (PCB) design, soldering, and prototyping. Completed 12-bit breadboard computer using von Neumann architecture and custom machine code, for which various algorithms (*e.g.*, Fibonacci sequence, Collatz conjecture) and rudimentary games were manually programmed. Have designed and developed custom projects using Arduino Nano, Uno, and Mega microcontrollers; notable products are MIDI controllers, holiday ornaments with adjustable lights and music, and multipurpose LED arrays featuring Bluetooth control and dedicated Android app.

**Music production**
18 years experience with digital audio workstations (DAWs) with preference for FL Studio. Extensive knowledge of additive and subtractive synthesis, sound design, recording, mixing, and mastering.

**Miscellaneous**
Capable with HTML, Javascript, and Fortran, with exposure to website development, parallel programming, and high-performance computing (HPC). Considerable experience with LaTeX typesetter.

## Outreach

**SPARK Center Science Day** (*Morgantown, WV*)
Led basic physics demonstrations for elementary school children.

## References

**Dr. Paul Cassak**
Professor of Physics, Clemson University
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**Dr. Earl Scime**
Professor of Physics, West Virginia University
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**Dr. Thomas Steinberger**
Assistant Professor of Physics, West Virginia University
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