

Mohammadreza Zakeri

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Research Interests

My research forms a bridge between particle physics beyond the Standard Model and astrophysics, with a specific focus on the theoretical implications for the high-density environments of neutron star interiors. I explore how interactions within these stars might link astrophysical phenomena at large scales—such as pulsar spin and binary system dynamics—to the underlying principles of particle physics, particularly baryon number violation. In my investigations of new particles and symmetries, I draw on my background in particle physics model building. This experience comprises of skills needed for tackling questions surrounding the origins of dark matter and neutrino mass, and discerning their experimental signatures, both in colliders and underground detectors.

Professional Experience

- 2021 - Now **Postdoctoral Scholar**, *University of Kentucky*, Lexington, KY.
- Conducting interdisciplinary research at the interface of particle physics and astrophysics, focusing on theoretical implications for neutron star interiors.
 - Engaging in collaborative model development and theoretical explorations linking subatomic particle behaviors to astrophysical observations like pulsar spin and binary system dynamics.
 - Mentoring a graduate student through the Start-to-Finish Mentorship Program, focusing on priority setting, networking, career planning, and counseling in line with the program's goal to support historically underrepresented students.
 - *Co-organizer*: Nuclear Seminar (2023-24), Department of Physics & Astronomy.
 - *Co-organizer*: Nuclear Seminar (2022-23), Department of Physics & Astronomy.
 - *Co-organizer*: Theory Seminar (2021-22), Department of Physics & Astronomy.
- Feb 2021 **Teacher**, *Saint Paul American School*, Beijing, China.
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Jun 2021
- Taught Advanced Placement (AP) Chemistry and 10th Grade Chemistry, including curriculum development, lesson planning, and student assessment.
- 2017 - 2021 **Postdoctoral Researcher**, *Institute of Theoretical Physics, CAS*, Beijing, China.
- Led research on cosmic ray signals from dark matter in the Sun, analyzing time-dependent signals in space-based experiments AMS-02, DAMPE, and CALET.
 - Awarded the "CAS President's International Fellowship Initiative (PIFI)" in 2019 for my proposal titled "Dark Matter; Origin and Probes," underpinning the research conducted.
 - Collaborated with an international team, fostering cross-cultural scientific exchange and teamwork.
- 2012 - 2017 **Teaching Assistant**, *University of California, Riverside*, Riverside, California.
- Provided comprehensive teaching support across a broad range of physics courses, including General Physics, Quantum Mechanics, and Thermodynamics.
 - Led discussion sessions, office hours, and laboratory classes, enhancing student understanding and engagement in complex physics concepts.
 - Proctored and graded exams, contributing to accurate and fair assessments of student performance.
 - Developed and instructed a Physics GRE Preparation Course, assisting students in achieving competitive scores for graduate school applications.
 - Recognized with the "Outstanding Teaching Assistant Award" from the Department of Physics & Astronomy at UCR in 2017 for exceptional teaching performance and student engagement.

Education

- 2012-2017 **PhD in Physics (2017) and MS in Physics (2013)**, *University of California, Riverside*, Riverside, California.
- Advisor: Professor Ernest Ma
 - PhD Thesis: “Extensions of the Standard Model with Dark Matter in Some Explicit Examples”
 - Recipient of the Dean’s Distinguished Fellowship, providing \$216K in total support over the course of the graduate program.
 - Awarded two GSA Conference Travel Grants in 2016 and one in 2017, for presenting research at conferences.
- 2008-2012 **BS Physics**, *Sharif University of Technology*, Tehran, Iran.

Publications

1. **Probing Dark Sectors with Neutron Stars**, *S. Gardner and M. Zakeri*, Accepted in Universe. [arXiv: 2311.13649].
2. **Pulsar Timing Anomalies: A Window into Baryon Number Violation**, *M. Zakeri*, Submitted to JCAP. [arXiv: 2311.05586].
3. **How Macroscopic Limits on Neutron Star Baryon Loss Yield Microscopic Limits on Non-Standard-Model Baryon Decay**, *J. M. Berryman, S. Gardner, M. Zakeri*, Phys. Rev. D 109, 023021 [arXiv: 2305.13377].
4. **Neutron Stars with Baryon Number Violation, Probing Dark Sectors**, *J. M. Berryman, S. Gardner, M. Zakeri*, Symmetry 14 (2022) 518, [arXiv:2201.02637].
5. **Constraining Time Dependent Dark Matter Signals from the Sun**, *M. Zakeri, Y. F. Zhou*, JCAP 04 (2022) 04, 026, [arXiv:2109.11662].
6. **Exotic Lepton-Flavor Violating Higgs Decays**, *J. A. Evans, P. Tanedo, M. Zakeri*, JHEP 01 (2020) 028, [arXiv:1910.07533].
7. **Non-Abelian Vector Boson as FIMP Dark Matter**, *B. Barman, S. Bhattacharya, M. Zakeri*, JCAP 02 (2020) 029, [arXiv:1905.07236].
8. **Multipartite Dark Matter in $SU(2)_N$ Extension of Standard Model and Signatures at the LHC**, *B. Barman, S. Bhattacharya, M. Zakeri*, JCAP 09 (2018) 023, [arXiv:1806.01129].
9. **A Minimal Model For Two-Component FIMP Dark Matter: A Basic Search**, *S. P. Zakeri, S. M. MoosaviNejad, S. Y. Ayazi, M. Zakeri*, Chin. Phys. C42 (2018) no.7, 073101, [arXiv:1801.09115].
10. **Alternative $[SU(3)]^4$ Model of Leptonic Color and Dark Matter**, *C. Kownacki, E. Ma, N. Pollard, O. Popov, M. Zakeri*, Nucl. Phys. B928 (2018) 520-534, [arXiv:1801.01379].
11. **Dark Revelations of the $[SU(3)]^3$ and $[SU(3)]^4$ Gauge Extensions of the Standard Model**, *C. Kownacki, E. Ma, N. Pollard, O. Popov, M. Zakeri*, Phys. Lett. B777 (2018) 121-124, [arXiv:1710.00762].
12. **Dark Gauge $U(1)$ Symmetry for an Alternative Left-Right Model**, *C. Kownacki, E. Ma, N. Pollard, O. Popov, M. Zakeri*, Eur. Phys. J. C78 (2018) no.2, 148, [arXiv:1706.06501].
13. **Quartified Leptonic Color, Bound States, and Future Electron-Positron Collider**, *C. Kownacki, E. Ma, N. Pollard, O. Popov, M. Zakeri*, Phys. Lett. B769 (2017) 267-271, [arXiv:1701.07043].
14. **Generalized Gauge $U(1)$ Family Symmetry for Quarks and Leptons**, *C. Kownacki, E. Ma, N. Pollard, M. Zakeri*, Phys. Lett. B766 (2017) 149-152, [arXiv:1611.05017].
15. **Gauge $B-L$ Model of Radiative Neutrino Mass with Multipartite Dark Matter**, *E. Ma, N. Pollard, O. Popov, M. Zakeri*, Mod. Phys. Lett. A31 (2016) no. 27, 1650163, [arXiv:1605.00991].

16. **Phenomenology of the Utilitarian Supersymmetric Standard Model**, *S. Fraser, C. Kownacki, E. Ma, N. Pollard, O. Popov, M. Zakeri*, Nucl. Phys. B 909, 644 (2016), [arXiv:1603.04778].
17. **Verifiable Associated Processes from Radiative Lepton Masses with Dark Matter**, *S. Fraser, E. Ma, M. Zakeri*, Phys. Rev. D 93, 115019 (2016), [arXiv:1511.07458].
18. **Gauge B–L Model with Residual Z_3 Symmetry**, *E. Ma, N. Pollard, R. Srivastava, M. Zakeri*, Phys. Lett. B750 (2015) 135-138, [arXiv:1507.03943].
19. **$SU(2)_N$ Model of Vector Dark Matter with a Leptonic Connection**, *S. Fraser, E. Ma, M. Zakeri*, Int. J. Mod. Phys. A 30, 1550018 (2015), [arXiv:1409.1162].

Presentations

1. **Pulsars as Laboratories for Fundamental Physics**, *Physics Department Nuclear Seminar*, University of Kentucky.
Lexington, KY, USA, Jan 2024
2. **Neutron Stars: Exploring the Dense Wonders of the Cosmos**, *Invited Public Outreach Talk: Kentucky SkyTalk*, University of Kentucky.
Lexington, KY, USA, Nov 2023
3. **How Binary-Pulsar Orbital Period Measurements Constrain Baryon Dark Decays**, *Conference Talk: CETUP 2023*, Sanford Underground Research Facility (SURF).
Lead, South Dakota, USA, Jun 2023
4. **Constraining Baryon Number Violation with Neutron Stars**, *Invited Talk: High-Energy Physics Seminar*, University of Stavanger.
Stavanger, Norway, Dec 2022
5. **Constraining Baryon Number Violation with Neutron Stars**, *Invited Talk: High Energy Physics Seminar*, University of California, Riverside.
Riverside, CA, USA, Nov 2022
6. **Constraining Baryon Number Violation with Neutron Stars**, *Conference Talk: PIKIMO 13*, University of Cincinnati.
Cincinnati, OH, USA, Nov 2022
7. **Constraining Baryon Number Violation with Neutron Stars**, *Invited Talk: High Energy/Astrophysics Seminar*, University of Cincinnati.
Cincinnati, OH, USA, Oct 2022
8. **Possible Baryon Number Violation in Neutron Stars**, *Conference Talk: Neutron Rich Matter on Heaven and Earth (INT-22-2A)*.
Seattle, WA, USA, Jul 2022
9. **Baryon Number Violation in Neutron Stars**, *Conference Talk: XV International Conference on Interconnections between Particle Physics and Cosmology*.
St. Louis, MO, USA, Jun 2022
10. **Baryon Number Violation in Neutron Stars**, *Physics Department Theory Seminar*, University of Kentucky.
Lexington, KY, USA, Jan 2022
11. **Dark Matter Solar Signals**, *Conference Talk: ITP Postdoctoral Symposium*, Institute of Theoretical Physics, Chinese Academy of Sciences.
Beijing, China, May 2020

12. **Exotic Lepton-Flavor Violating Higgs Decays**, *Conference Talk: New physics beyond the Standard Model (PICTP program)*.
Beijing, China, Oct 2019
13. **Dark Gauge U(1) and the DAMPE Signal**, *Poster: KEK Theory Meeting 2018(KEK-PH2018)*.
Tsukuba, Japan, Feb 2018
14. **Leptonic Color, and the Future Electron-Positron Collider**, *Journal Club Talk*, Institute of Theoretical Physics, Chinese Academy of Sciences.
Beijing, China, Nov 2017
15. **Gauge B–L Model with Residual Z_3 Symmetry**, *Invited Talk: BLV 2017*.
Cleveland, OH, USA, May 2017
16. **Quantified Leptonic Color, Bound States, and Future Electron-Positron Collider**, *Journal Club Talk*, University of California, Riverside.
Riverside, CA, USA, May 2017
17. **Leptonic Color, and the Future Electron-Positron Collider**, *Invited Talk*, Institute of Modern Physics, Chinese Academy of Sciences.
Lanzhou, China, Dec 2016
18. **Asymmetric Reheating After Inflation**, *Poster: COSMO-16*.
Ann Arbor, MI, USA, Aug 2016
19. **Radiative Lepton Masses**, *Conference Talk: Phenomenology 2016 Symposium*.
Pittsburgh, PA, USA, May 2016

Conferences & Schools

1. **CETUP 2023**, Lead, SD, USA, Jun-Jul 2023
2. **PIKIMO-13**, Cincinnati, OH, USA, Nov 2022
3. **Neutron Rich Matter on Heaven and Earth (INT-22-2A)**, Seattle, WA, USA, Jul 2022
4. **Neutrino Theory Network Workshop**, Fermilab, IL, USA, Jun 2022
5. **XV International Conference on Interconnections between Particle Physics and Cosmology**, St. Louis, MO, USA, Jun 2022
6. **ITP Postdoctoral Symposium**, Beijing, China, May 2020
7. **PICTP program: New physics beyond the Standard Model**, Beijing, China, Oct 2019
8. **KEK Theory Meeting 2018(KEK-PH2018)**, Tsukuba, Japan, Feb 2018
9. **Winter School on Gravitational-Wave Data Analysis**, Beijing, China, Dec 2017
10. **International Workshop on Baryon & Lepton Number Violation 2017**, Cleveland, OH, USA, May 2017
11. **SOCAL BSM 2017**, Riverside, CA, USA, Apr 2017
12. **COSMO-16**, Ann Arbor, MI, USA, Aug 2016
13. **TASI Summer School**, Boulder, CO, USA, June-July 2016
14. **Phenomenology 2016 Symposium**, Pittsburgh, PA, USA, May 2016

Teaching Experiences

Saint Paul American School, Beijing, China

Spring 2021 *Teacher*, AP Chemistry

Spring 2021 *Teacher*, Chemistry (10th Grade)

University of California, Riverside, Riverside, California

- Summer 2017 *Teaching Assistant*, PHYS 040B: General Physics Laboratory
Spring 2017 *Teaching Assistant*, PHYS 040B: General Physics
Winter 2017 *Teaching Assistant*, PHYS 02LB: General Physics Laboratory
Fall 2016 *Course Grader*, PHYS 221A: Quantum Mechanics
Teaching Assistant, PHYS 156A: Quantum Mechanics
Summer 2016 *Instructor*, Physics GRE Preparation Course
Spring 2016 *Course Grader*, PHYS 221C: Quantum Mechanics
Course Grader, PHYS 212B: Thermodynamics And Statistical Mechanics
Winter 2016 *Course Grader*, PHYS 221B: Quantum Mechanics
Teaching Assistant, PHYS 156B: Quantum Mechanics
Fall 2015 *Course Grader*, PHYS 221A: Quantum Mechanics
Teaching Assistant, PHYS 156A: Quantum Mechanics
Summer 2015 *Instructor*, Physics GRE Preparation
Spring 2015 *Course Grader*, PHYS 221C: Quantum Mechanics
Teaching Assistant, PHYS 040B: General Physics
Winter 2015 *Course Grader*, PHYS 221B: Quantum Mechanics
Teaching Assistant, PHYS 156B: Quantum Mechanics
Fall 2014 *Course Grader*, PHYS 221A: Quantum Mechanics
Teaching Assistant, PHYS 156A: Quantum Mechanics
Summer 2014 *Teaching Assistant*, PHYS 040C: General Physics
Spring 2014 *Teaching Assistant*, PHYS 040C: General Physics
Winter 2014 *Teaching Assistant*, PHYS 02LB: General Physics Laboratory
Fall 2013 *Teaching Assistant*, PHYS 040C: General Physics Laboratory
Summer 2013 *Teaching Assistant*, PHYS 040C: General Physics Laboratory
Spring 2013 *Teaching Assistant*, PHYS 040C: General Physics Laboratory
Winter 2013 *Teaching Assistant*, PHYS 02LB: General Physics Laboratory
Fall 2012 *Teaching Assistant*, PHYS 02LA: General Physics Laboratory

Computer Skills

- Programming **Python**: Proficient (2 years). Libraries: NumPy, SciPy, matplotlib, pandas, sklearn.
C++: Experienced (6 years). Libraries: gsl, root, omp, standard libraries.
- HEP Tools MadGraph, PYTHIA, Root, FastJet, FeynRules, FeynCalc, FeynArts, CalcHEP, SARAH
- Software Linux, \LaTeX , Mathematica, Xcode, MATLAB, Inkscape, Affinity Designer
- Original **CompactStar** (C++): Analysis of compact star structures.
Software **DMSS** (C++): Dark Matter Solar Signals analysis for specific dark matter models.
CONFIND (C++): Contour finding based on CONREC subroutine with multithreading.
Pheno (Python & C++): Collider analysis with PYTHIA & FastJet, featuring user-defined event cuts and multiprocessing.

Languages

- Proficiency Farsi (Mother tongue and native fluency), English (Native fluency), Mandarin (Basic)

References

- **Gardner, Susan**, *Email: svg@pa.uky.edu, Professor at University of Kentucky, Lexington, KY, USA.*
- **Machado, Pedro**, *Email: pmachado@fnal.gov, Associate Scientist at Fermi National Accelerator Laboratory, IL, USA.*
- **Tanedo, Flip**, *Email: flip.tanedo@ucr.edu, Associate Professor at University of California, Riverside, CA, USA.*
- **Ma, Ernest**, *Email: ma@phyun8.ucr.edu, Professor Emeritus at University of California, Riverside, CA, USA.*
- **Zhou, Yu-Feng**, *Email: yfzhou@itp.ac.cn, Professor at Institute of Theoretical Physics (ITP), Beijing, China.*
- **Aiello, Gregory**, *Email: aiello.gregory.7@gmail.com, Principal at Saint Paul American School, South Korea.*