Zack Carson, PhD – CV

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Astrophysicist and data scientist with 10 years of academic and industry experience eager to leverage my varied skill set to drive innovative and impactful contributions to space exploration and technology. My background combines astrophysics research, education, and data science/machine learning (ML) to uniquely position me as an adaptable, fast-learning, and highly motivated transplant into the aerospace field.

Experience

Orbital Analyst, United States Space Force – NSDC, Schriever SFB, CO 2025 – Present

Providing space situational domain awareness for impact on DoD, AF, USSF, USSPACECOM, Intelligence Communities, and other entities with timely and accurate satellite positional data on all man-made satellites and orbital debris.

Data Scientist III (Machine Learning), Dataminr – New York City, NY 2021 – 2025

Builds text and image based machine learning (ML) models used to detect alertable content for both public and private sector customers utilizing public data streams.

ACCOMPLISHMENTS:

- Established 2,000+ net new ML-generated alerts to clients daily by designing and implementing 5 new text/image ML models (Python) running live on 1 billion inputs per day from 100,000 data sources
- Led the AI cybersecurity team to enrich client alerts with relevant information by designing and implementing a self-ingesting knowledge graph (Neo4j, Cypher, Airflow) containing 1 million+ entities
- Achieved sub-5 minute latency on a live data streaming and reduction pipeline (Databricks, Spark), enabling social media anomaly detection by filtering and aggregating 1 billion raw messages per day

RESPONSIBILITIES:

- Lead the Cyber AI team tasked with the detection of cyber security threats and vulnerabilities towards clients using ML models
- Collaborate with a team of 22 scientists through pair programming, model planning, and code reviews
- Collaborate with stakeholders and leadership to design and implement reliable ML models
- Present complex data, metrics, and visualizations in a digestible way to leadership and stakeholders
- Analyze internal usage data to identify patterns and increase efficiency of human-in-the-loop alerting
- Design and implement human annotation tasks to collect high-quality labeled data to train more performant models

TECHNICAL SKILLS:

- Python, SQL, Neo4j, Databricks, Spark, Amazon Web Services (AWS), Scala, Snowflake, Airflow, HTML, Git

Gravitational Wave Outreach Scientist (NSF Funded), University of Virginia – Charlottesville, VA 2021 – Present

Collaborate with and lead undergraduate and high school students to build educational outreach video games to teach students about orbital mechanics and gravitational waves generated by binary black hole and neutron star binary mergers. This work is sponsored by an NSF grant co-applied for with Dr. Kent Yagi.

ACCOMPLISHMENTS:

- Leads a team of undergraduates in developing 2 new educational GR games by providing astrophysics expertise
- Designed and implemented an outreach game (Unity, C#) used in classrooms – "Gravitational Wave Surfer" – by translating complex principles of general relativity (GR) into digestible and engaging game mechanics

RESPONSIBILITIES:

- Design and create engaging and educational video games in Unity using principles of general relativity and gravitational radiation
- Translate complex information into an easily understandable format to be communicated to laypersons and students around the world
- Hire, manage, and mentor undergraduate and high school students to plan, design, and create educational video games in Unity

TECHNICAL SKILLS:

- Unity, C#, NASA General Mission Analysis Tool (GMAT)

Data Scientist (Machine Learning), TruU – Boulder, CO 2020 – 2021

Planned and created biometric machine learning (ML) models used by customers as a security measure to verify the identity of their employees while in the office.

ACCOMPLISHMENTS:

- Enabled net new biometric authentication features on 100% of customer devices by designing and implementing 3 new ML models (Python) running on live gait and typing cadence data

RESPONSIBILITIES:

- Collaborated with stakeholders to implement, optimize, and deploy biometric ML models
- Collaborated with a team of 5 colleagues via pair programming sessions and code reviews
- Presented visualizations of results, metrics, and data analyses to stakeholders and leadership
- Designed, managed, and maintained internal databases on company-owned servers

TECHNICAL SKILLS:

- Python, SQL, Git

Astrophysics Graduate Research Scientist, University of Virginia – Charlottesville, VA 2015 – 2020

Graduate level physics researcher focused on the following subjects:

- My primary research focus with Professor Kent Yagi utilized the gravitational radiation emitted from binary black hole and neutron star mergers detected by LIGO (Laser Interferometer Gravitational-wave Observatory) to probe various aspects of fundamental physics - such as General Relativity and the structure of supranuclear matter
- Earlier in my career I worked in an optics laboratory investigating quantum computing using entangled, squeezed qumodes (the continuous-variable counterpart to qubits) of multimodal light
- Starting my career I worked with a high energy group investigating the Higgs boson decay modes and microscopic black hole production in collaboration with CERN

For more details on my research, see my personal website.

ACCOMPLISHMENTS:

- Published 17 astrophysics articles (LaTeX, XMGrace) – 13 as the lead author – with 638 citations in leading peer-reviewed journals by collaborating with Laser Interferometer Space Antenna (LISA), Laser Interferometer Gravitational-wave Observatory (LIGO), and other observatories to use gravitational and electromagnetic signals to test GR and study the neutron star interior (Matlab, Mathematica)
- Presented my research at 6 astrophysics conference proceedings – 2 as an invited speaker – representing the discoveries made after combining observational data with theoretical and analytical work
- Single recipient of the 2020 University of Virginia Distinguished Research Fellowship Award for leading innovative theoretical and observational astrophysics research resulting in limits placed on theoretical physics parameters
- Achieved a record-holding 3.2 dB of quantum noise reduction in entangled photons used for quantum computing by designing and building an optical parametric oscillator (OPO) cavity housing a custom frequency-doubling crystal
- Produced code (C++) used among the European Council for Nuclear Research (CERN) community by using decision trees to profile the Higgs boson decay signal

RESPONSIBILITIES:

- Performed leading theoretical, analytical, and experimental research as summarized above
- Traveled to conferences as both invited and contributing speakers to present my research to audiences with all levels of physics experience
- Wrote and published the results of my research in various peer-reviewed journals
- Co-advised undergraduate students on gravitational wave research

TECHNICAL SKILLS:

- NASA General Mission Analysis Tool (GMAT), Scientific laboratory equipment, high precision machining, electronics, optics, Mathematica, Matlab, C++, Python, Fortran, LaTeX, Git, XMgrace

Lead Graduate Teaching Assistant, University of Virginia – Charlottesville, VA 2014 – 2019

Lead Teaching Assistant (“Super TA”) involved with teaching, training, and grading.

ACCOMPLISHMENTS:

- Designed and implemented 24 new undergraduate physics labs to foster innovation, creativity, and engagement by transforming old instruction-based labs into exploration-based mechanics and electromagnetism experiments

- Developed a new graduate teaching assistant (TA) training program to train 15-20 incoming students yearly by implementing a 2-week bootcamp filled with think tanks, lectures, and mock-teaching simulations
- Single recipient of the 2019 University of Virginia Distinguished Graduate STEM Teaching Award for 4 years of teaching labs and lectures with a 98% student approval rating, innovative curriculum redesign, and graduate TA leadership

RESPONSIBILITIES:

- Oversaw the training of the physics lab TAs
- Collaborated with Professor Maksim Bychkov to develop a new teaching curriculum to produce more viable, confident, and motivated teaching assistants
- Instructed mechanics and electromagnetism labs and discussion sessions
- Served as the official grader for several graduate level physics courses

TECHNICAL SKILLS:

- Scientific laboratory equipment

Astronomy Outreach Scientist, University of Utah – Salt Lake City, VA 2011 – 2014

Astronomy outreach scientist at the University of Utah observatory working to foster astronomy education outreach to the general public locally and across the state of Utah.

RESPONSIBILITIES:

- Traveled to various K-12 schools, boy scout groups, and other organizations to run demos, teach astronomy, and use telescopes
- Hosted weekly "Star Parties" at the observatory, where the general public came to learn about astronomy and use the various telescopes

TECHNICAL SKILLS:

- Telescope operation and maintenance

Skills

Technical: NASA General Mission Analysis Tool (GMAT), Scientific laboratory equipment, electronics, optics, telescope operation and maintenance, machining, Git, Unity
Programming Languages: Python, SQL, Cypher, Matlab, Mathematica, Scala, LaTeX, XMgrace, C#, C++, HTML, R
Data: Databricks, Spark, Amazon Web Services (AWS), Neo4j, Snowflake, Airflow

Education

University of Virginia 2020
Doctor of Philosophy in Physics, Thesis: Probing Fundamental Physics with Gravitational Waves, Advisor: Prof. Kento Yagi

University of Utah 2014
Bachelor of Science in Pre-Professional Physics, minor in astrophysics

University of Utah 2014
Bachelor of Science in Applied Mathematics

Academic Services

- Referee for Nature Astrophysics, Physical Review letters and D (PRL, PRD) and the Monthly Notices of the Royal Astronomical Society (MNRAS) academic journals
- Associate member of the Laser interferometer space antenna (LISA) consortium, where I completed analyses contemplating tests of General Relativity using various configurations of the LISA interferometer.
- University of Virginia Machine Shop certification

Honors

- University of Virginia department of Physics Research Fellowship Award 2020
- University of Virginia Distinguished Graduate Teaching Award for STEM fields (single recipient) 2019
- University of Virginia Physics Department Poster Competition, 2nd place. 2019
- Google PhD Fellowship Program nominee (one of two from University of Virginia) 2018
- Graduate Physics Students Association Vice President - University of Virginia 2016
- Eugene Loh "Fly's Eye Cosmic Ray" Scholarship - Awarded for Physics academic merit 2010-2014
- Alsco Scholarship - Awarded for academic merit 2010-2014
- Joseph Turner Crockett Memorial Scholarship - Awarded for science academic merit 2012-2013
- Questar Scholarship - Awarded for academic merit 2011

Conferences and Presentations

1. "Multi-messenger probes of the neutron star equation of state" (Invited Speaker) – *Southeastern Section of the American Physical Society (SESAPS) meeting, Wrightsville, NC, November 2019*
2. "Probing beyond-Kerr spacetimes with the IMR consistency tests of gravitational waves" (Contributed Speaker) – *APS April Virtual Meeting, April 2020*
3. "Universal relations after GW170817" (Contributed Speaker) – *APS April Meeting, Denver Colorado, April 2019*
4. "Constraining nuclear matter parameters and improving Universal Relations after GW170817" (Web seminar invited speaker, https://www.youtube.com/watch?v=Xt_9D931lyw) – *Nuclear Theory Group (hosted by Dr. Bharat Kumar, University of Tsukuba, Japan), March 2019*
5. "Universal relations after GW170817" (Poster presentation) – *GWPAW, University of Maryland, December 2018*
6. "Team based design of science laboratories" – *Innovation in Pedagogy Summit, University of Virginia 2016*

Publications

1. **Carson, Zack**. (2020). *Probing fundamental physics with gravitational waves* (Doctoral dissertation, University of Viginia). Retrieved from https://doi.org/10.18130/v3-pxdw-2144
2. **Carson, Zack**, & Yagi, K. (Eds.). (2021). *Testing General Relativity with Gravitational Waves,* submitted as a chapter of the *"handbook of gravitational wave astronomy"* by C. Bambi, S. Katsanevas and K. Kokkotas; Springer Singapore.
3. **Carson, Zack**, & Yagi, K. (2020e). Probing string-inspired gravity with the inspiral-merger-ringdown consistency tests of gravitational waves. *Class. Quantum Grav.*. Retrieved from https://doi.org/10.1088/1361-6382/aba221
4. **Carson, Zack**, & Yagi, K. (2020d). Probing einstein-dilaton gauss-bonnet gravity with the inspiral and ringdown of gravitational waves. *Phys. Rev. D*, *101*, 104030. Retrieved from https://link.aps.org/doi/10.1103/PhysRevD.101.104030
5. **Carson, Zack**, & Yagi, K. (2020a). Asymptotically flat, parameterized black hole metric preserving Kerr symmetries. *Phys. Rev. D*, *101*, 084030. Retrieved from https://link.aps.org/doi/10.1103/PhysRevD.101.084030
6. **Carson, Zack**, & Yagi, K. (2020c). Probing beyond-Kerr spacetimes with the inspiral-ringdown signals of gravitational waves. *Phys. Rev. D*, *101*, 084050. Retrieved from https://link.aps.org/doi/10.1103/PhysRevD.101.084050
7. **Carson, Zack**, & Yagi, K. (2020b). Parameterized and inspiral-merger-ringdown consistency tests of gravity with multiband gravitational wave observations. *Phys. Rev. D*, *101*, 044047. Retrieved from https://link.aps.org/doi/10.1103/PhysRevD.101.044047
8. Zimmerman, J., **Carson, Zack**, Schumacher, K., Steiner, A. W., & Yagi, K. (2020). Measuring Nuclear Matter Parameters with NICER and LIGO/Virgo. *Phys. Rev. Letters (under review)*. Retrieved from https://arxiv.org/abs/2002.03210
9. **Carson, Zack**, & Yagi, K. (2019a). Multi-band gravitational wave tests of general relativity. *Classical and Quantum Gravity Letters*. Retrieved from https://iopscience.iop.org/article/10.1088/1361-6382/ab5c9a

10. **Carson, Zack**, & Yagi, K. (2019b). Parameterized and Consistency Tests of Gravity with Gravitational Waves: Current and Future. In *Proceedings, Recent Progress in Relativistic Astrophysics: Shanghai, China, May 6-8, 2019* (Vol. 17(1)). Retrieved from https://doi.org/10.3390/proceedings2019017005

11. **Carson, Zack**, Seymour, B. C., & Yagi, K. (2020). Future Prospects for Probing Scalar-Tensor Theories with Gravitational Waves from Mixed Binaries. *Class. Quant. Grav*, *37*(6), 065008. Retrieved from https://doi.org/10.1088%2F1361-6382%2Fab6a1f

12. Tahura, S., Yagi, K., & **Carson, Zack**. (2019). Testing Gravity with Gravitational Waves from Binary Black Hole Mergers: Contributions from Amp. Corrections. *Phys. Rev.*, *D100*(10), 104001. Retrieved from https://doi.org/10.1103/PhysRevD.100.104001

13. **Carson, Zack**, Chatziioannou, K., Haster, C.-J., Yagi, K., & Yunes, N. (2019). Equation-of-state insensitive relations after GW170817. *Phys. Rev.*, *D99*(8), 083016. Retrieved from https://doi.org/10.1103/PhysRevD.99.083016

14. **Carson, Zack**, Steiner, A. W., & Yagi, K. (2019a). Constraining nuclear matter parameters with GW170817. *Phys. Rev.*, *D99*(4), 043010. Retrieved from https://doi.org/10.1103/PhysRevD.99.043010

15. **Carson, Zack**, Steiner, A. W., & Yagi, K. (2019b). Future Prospects for Constraining Nuclear Matter Parameters with Gravitational Waves. *Phys. Rev.*, *D100*(2), 023012. Retrieved from https://doi.org/10.1103/PhysRevD.100.023012

16. Zang, J., ..., **Z. Carson**, ..., & Campbell, J. C. (2017). High quantum efficiency uni-traveling-carrier photodiode. *IEEE Phot. Tech. Letters*, *29*(3), 302-305. Retrieved from https://doi.org/10.1109/LPT.2016.2647638

17. Zhu, X., **Carson, Zack**, Alexander, R., & Pfister, O. (n.d.). Leveraging qumode scalability: high squeezing and entanglement from redistributed multitudinous-mode squeezing. *(in progress)*.