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Research Interest

Dark matter; Early universe; Supermassive black holes; Galaxy formation; Population III stars; Cosmological perturbation theory; Large-scale structure of the universe; Primordial galaxies; Strong gravitational lensing; Infrared photometry; Massive stars

Education

- Aug. 2020 – Aug. 2026 (exp.) **Doctor of Philosophy in Physics**, advisor: **Volker Bromm**
University of Texas at Austin, TX, USA
Ph.D. Thesis: *Imprints of the Primordial Black Holes over Cosmic History*
- Aug. 2020 – Dec. 2024 **Master of Arts in Physics**, advisor: **Katherine Freese**
University of Texas at Austin, TX, USA
Master Thesis: *Detecting Supermassive Dark Stars with the Roman Space Telescope*
- Aug. 2015 – May. 2019 **Bachelor of Arts in Astronomy/Physics with Honors & Applied Mathematics**, advisor: **Cosmin Ilie**
Magna cum laude, Colgate University, NY, USA
Undergraduate Thesis: *Multi-scatter Capture of Super Heavy Dark Matter by the First Stars*

Research Experience

University of Texas at Austin:

- 2022 – Present **Graduate Research Assistant**, Advisor: **Volker Bromm**
Project: *Imprints of the Primordial Black Holes over Cosmic History*
- Formulated analytical models to investigate astrophysical effects by primordial black holes in terms of radiation feedback and structure formation .
 - Optimized GIZMO's N-body and Hydrodynamic code in C/C++ and generated the initial condition to include primordial black hole in simulations.
 - Executed cosmological simulations to analyze the universe's dynamics influenced by primordial black holes, building and managing data pipelines with Python and Bash Scripts for comprehensive analysis.
 - With simulated results, made comparisons with existing observation signals by JWST and predicted signatures of primordial black holes for future survey.

- 2025 – Present **Research Student**, Research Supervisor: **Arya Farahi**
Project: *DREAMS Project w/ Warm Dark Matter*
- Analyzed large-scale hydrodynamical simulations from The DREAMS Project to study Warm Dark Matter effects on galaxy formation and evolution.
 - Built Python pipelines to aggregate halo catalog data and computed best fitting parameters and statistical trends with the supervised learning method.
- 2021 – 2024 **Graduate Research Assistant**, Advisor: **Katherine Freese**
Project: *Detection of the Dark Stars by JWST/Roman Telescopes*
- Utilized the Pandeia simulation tool and TLUSTY package for modeling and predicting observational signatures of Dark Stars by Roman Telescopes.
 - Integrated HST and JWST observational data into the models, enhancing the robustness and reliability of the simulations and emphasizing both theoretical and data-driven methods.
- Colgate University:**
- 2018 – 2020 **Research Assistant**, Thesis Advisor: **Cosmin Ilie**
Project: *Dark Matter Capture by Massive Objects*
- Studied several models for dark matter captured by massive objects and verified simulations from literature using MATLAB.
 - Improved on the existing formulism adopted from literature and ran new simulations for dark matter capture by the first stars and neutron stars.
 - Gave constraints to the Dark matter-baryon interaction strength by stellar evolution model and possible observations.
- 2019 **Research Student**, Thesis Advisor: **Aaron Robertson**
Project: *Monte-Carlo Method on Elliptical Integral*
- Compiled programs on MATLAB to investigate the performance of Monte-Carlo Method on evaluating elliptical and other complex integrals, compared it with other algorithms
 - Analyzed and found the trend of the error between the evaluation and the true value, and extended this method to higher dimension integrals.
- 2017 **Summer Research Assistant**, Research Supervisor: **Enrique Galvez**
Project: *Polarization of Gaussian Beams*
- Assembled the lab setup and measured the data from the interference pattern of the polarized beams of the higher order.
 - Improved the existing program for the Spatial Light Modulator with MATLAB.
- 2016 – 2017 **Summer Research Assistant**, Research Supervisor: **Thomas Balonek**
Project: *Optical Variability of Quasars*
- Delegated to daily observations of a set of the quasars in order to monitor the changes in their brightness.
 - Learned how to use the telescope and CCD camera to take images, and collected data and made graphs to find variations in different time scale.

Presentation

Talks	(* for contributed/seminar talks, • for invited talks)
Dec. 2025	*Group Meeting Talk, Peking University, Beijing, China
Dec. 2025	*Texas Symposium on Relativistic Astrophysics, ASU, Tempe, AZ
Oct. 2025	*Extragalactic Discussion Group talks, University of Hawaii, Mānoa, HI
Sep. 2025	*Thunch Talk, Princeton University, Princeton, NJ
Sep. 2025	*Galaxy Lunch, Yale University, New Heaven, CT
Sep. 2025	*PACMAN Seminar, Flatiron Institute, New York City, NY
Sep. 2025	*Seminar, Columbia University, New York City, NY
Aug. 2025	*Santa Cruz Galaxy Workshop (video), UC Santa Cruz, CA
Apr. 2025	*ITC Luncheon Talk (video), Harvard University, Boston, MA
Apr. 2025	*MAT Seminar, MIT Kavli Institute, Boston, MA
Apr. 2025	*Group Meeting Talk, Carnegie Observatories, Pasadena, CA
Dec. 2024	*Group Meeting Talk, Tsinghua University, Beijing, China
Nov. 2024	*CFC-CCA Workshop, University of Texas, Austin, TX
Oct. 2024	•TEPAPP seminar, University of California, Los Angeles, CA
Oct. 2024	*Astrophysics Seminar, University of California, Riverside, CA
Jul. 2024	•Seventeenth Marcel Grossmann Meeting, Italy
Jul. 2024	*International Workshop on the Identification of Dark Matter, Italy
Apr. 2024	•Physics Seminar, Colgate University, Hamilton, NY
Apr. 2022	*APS April Meeting, New York City, NY
Oct. 2016	*Keck Northeast Astronomy Consortium, Wesleyan University, CT

Posters

May 2025	CFC2025, University of Texas, Austin, TX
Mar. 2025	Dark Matter 2025, University of California, Los Angeles, CA
May 2024	First Stars VII, Flatiron Institute, NY
Dec. 2023	Texas Symposium on Relativistic Astrophysics, Tsung-Dao Li Institute, SJTU, Shanghai, China
Jun. 2019	Symposium in Honor of the Legacy of Vera Rubin, Georgetown University, Washington DC
Mar. 2019	Rochester Symposium for Physics Students: SPS Regional Meeting, University of Rochester, Rochester, NY

Awards

UT Austin

2025	Dissertation Writing Fellowship (\$24000, recognition of achievement)
2024	Robert S. Davis and Lyell P. Davis Scholarship Fund (\$1000, merit-based)
2024/2025/2026	Graduate School Professional Development Award (\$2250)

APS

2022	APS DAP Student/Postdoc Travel Grant(\$600)
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Colgate Univ

2019	Joseph C. Amato & Anthony F. Aveni Award (Excellence in Thesis)
2016 – 2019	Dean's Award with Excellence (merit-based)
2016	Edwin Foster Kingsbury Prize (merit-based)
2016	Sisson Mathematics Prizes (\$500, merit-based)

Professional Experience

Proposals

- 2025 **JWST Director's Discretionary program**, Co-I, Cycle 4, DD [9433](#)
Title: *Black hole primacy - do supermassive black holes really predate galaxies?*
- 2024 **TACC HPC allocation**, Co-I, AST23026 (30,000 node-hours)
Title: *The First Stars and Galaxies*

Service

- 2025 – present Refereed for the **Astronomical Journal (AJ)**

Associations

- 2025 – Present **American Astronomical Society (AAS)**
 2016 – Present **American Physical Society (APS)**

Mentoring

UT Austin

- Kaitlyn Chang Directed Reading Program (outreach program) Mentee
 Undergraduate Student in Electronic Engineering Department, UT Austin
- Kyara Michelle Directed Reading Program (outreach program) Mentee
 Undergraduate Student in Astronomy Department, UT Austin
- Ken Nordhauser Research Mentee, Visiting Student in Physics Department, UT Austin

Colgate Univ

- Jillian Paulin Research Mentee on Detection of Dark Stars by JWST
 Current PhD Student in Physics Department, Univ. of Pennsylvania

Teaching

UT Austin

- Fall 2025 Grading Assistant, *PHY352K: Classical Electrodynamics I*
- Spring 2024 Grading Assistant, *PHY 362K Quantum Mechanics II: Atoms/Molecules*
- Fall 2023 Grading Assistant, *PHY 373 Quantum Mechanics I: Foundations*
- 2020 – 2025 Lab TA, *PHY 105M, PHY 105N, PHY 102N Labs for Physics II*
- Spring 2022 Grading Assistant, *PHY 352L Classical Electrodynamics II*

Colgate Univ

- Spring 2019 Math Tutor, *MATH 311 Partial Differential Equation*
- Fall 2018 Physics Tutor, *ASTR 210 Intermediate Astronomy and Astrophysics*
- Fall 2016 Physics Tutor, *PHYS 131 Atoms and Waves*

Skills

Relevant Training

Numerical Analysis; Numerical Linear Algebra; Stochastic Differential Calculus; Bayesian Statistical Analysis; High Performance Computing; Mathematics in Deep Learning; Scientific Machine Learning

Coding

Languages: Python, C/C++, R, MATLAB, Mathematica, Bash, Fortran
 Packages: PyTorch/SKLEARN, Pandas, TLUSTY, GIZMO, MUSIC, ROCKSTAR, YT, COLOSSUS, PANDEIA

Tools

VS Code, L^AT_EX, ChatGPT/DeepSeek, Git/Github, Jupyter Lab, Microsoft Office Suite

Languages

Chinese (native), English (advanced), Japanese(elementary)

Publications¹ [7 as first (co-)author *, h-index = 11 (from [NASA/ADS](#))]

Peer-reviewed Journals:

- *1. **Zhang, S.**, Liu, B., Bromm, V., & Kühnel, F. (2025). *Primordial Black Holes as Seeds for Extremely Overmassive AGN Observed by JWST*, Accepted by The Astrophysical Journal Letter, [arXiv:[2512.14066](#)].
- *2. **Zhang, S.**, Liu, B., & Bromm, V. (2025). *A Novel Formation Channel for Supermassive Black Hole Binaries in the Early Universe via Primordial Black Holes*, The Astrophysical Journal, 992(1), 136.,[arXiv:[2508.00774](#)].
3. Maiolino, R., ..., **Zhang, S.**, ..., et al. (2025). *A black hole in a near-pristine galaxy 700 million years after the Big Bang*, accepted by MNRAS, [arXiv:[2505.22567](#)].
- *4. **Zhang, S.**, Liu, B., Bromm, V., Jeon, J., Boylan-Kolchin, M., & Kühnel, F. (2025). *How do Massive Primordial Black Holes Impact the Formation of the First Stars and Galaxies*, The Astrophysical Journal, 987(2), 185., [arXiv:[2503.17585](#)].
- *5. **Zhang, S.**, Bromm, V., & Liu, B. (2024). *How do Primordial Black Holes change the Halo Mass Function and Structure*, The Astrophysical Journal, 975(1), 139., [arXiv:[2405.11381](#)].
- *6. **Zhang, S.**, Ilie, C., & Freese, K. (2024). *Detectability of Supermassive Dark Stars with the Roman Space Telescope*, The Astrophysical Journal, 965(2), 121., [arXiv:[2306.11606](#)].
- *7. **Zhang, S.**, Liu, B., & Bromm, V. (2023). *Distinguishing the impact and signature of black holes from different origins in early cosmic history*, MNRAS, 528, 180., [arXiv:[2310.01763](#)].
8. Liu, B., **Zhang, S.**, & Bromm, V. (2022). *Effects of stellar-mass primordial black holes on first star formation*, MNRAS, 514, 2376. (see also Nature Astronomy, 6, 881, 2022), [arXiv:[2204.06330](#)].
9. Ilie, C., Levy, C., Pilawa, J., & **Zhang, S.** (2020). *Constraining dark matter properties with the first generation of stars*, Phys. Rev. D, 104,123031., [arXiv: [2009.11474](#)].
10. Ilie, C., Pilawa, J., & **Zhang, S.** (2020). *Comment on “Multiscatter stellar capture of dark matter”*, Phys. Rev. D, 102, 048301. [arXiv:[2005.05946](#)].
- *11. Ilie, C., & **Zhang, S.** (2019). *Multiscatter capture of superheavy dark matter by Pop III stars*, Journal of Cosmology and Astroparticle Physics, 2019(12), 051., [arXiv:[1908.02700](#)].
12. Weaver, Z. R., Balonek, T. J., Jorstad, S. G., Marscher, A. P., Larionov, V. M., Smith, P. S., ... & **Zhang, S.** (2019). *The 2016 June Optical and Gamma-Ray Outburst and Optical Microvariability of the Blazar 3C 454.3*, The Astrophysical Journal, 875(1), 15., [arXiv:[1903.04587](#)].

Pre-prints, Errata and Conference Papers:

¹ORCID: [0000-0003-1541-177X](#)

13. Song, Z., ..., **Zhang, S.**, ..., et al. (2025). *Evaluating Large Language Models in Scientific Discovery*, submitted to Nature, [arXiv:2512.15567].
14. Übler, H., ..., **Zhang, S.**, ..., et al. (2025). *BlackTHUNDER: evidence for three massive black holes in a $z \sim 5$ galaxy*, submitted to A&A, [arXiv:2509.21575].
15. Juodžbalis, I., ..., **Zhang, S.**, ..., et al. (2025). *A direct black hole mass measurement in a Little Red Dot at the Epoch of Reionization*, submitted to Nature, [arXiv:2508.21748].
16. Ilie, C., & **Zhang, S.** (2020). *Erratum: Multiscatter capture of superheavy dark matter by Pop III stars*. Journal of Cosmology and Astroparticle Physics, 2020(10), E01.
17. Ilie, C., Pilawa, J., & **Zhang, S.** (2020). *Probing below the neutrino floor with the first generation of stars*, ArXiv Preprint. [arXiv:2009.11478].
18. Galvez, E. J., Dutta, I., & **Zhang, S.** (2018, November). *Möbius Polarization of Non-Collinear Poincare Superpositions*. In Latin America Optics and Photonics Conference (pp. Tu3D-2). Optica Publishing Group.

Astronomer's Telegrams:

1. Balonek, Thomas J., ..., **Saiyang Zhang**, ... et al. *Yet Another Extraordinary Optical Flare in the Blazar CTA 102 (Today's Brightest Quasar?)*. The Astronomer's Telegram 9808 (2016): 1.
2. Chapman, Katie J., ..., **Saiyang Zhang**, ... et al. *A Spectacular, Unprecedented Optical Flare in the Blazar CTA 102*, The Astronomer's Telegram 9756 (2016).
3. Balonek, Thomas J., **Saiyang Zhang**, et al. *Blazar CTA 102 Reaches Historic Optical Maximum During Current Extended Period of Activity*, The Astronomer's Telegram 9732 (2016).
4. Balonek, Thomas J., ..., **Saiyang Zhang**, ... et al. *Optical Observations of Correlated Outburst Activity in BL Lacertae*. The Astronomer's Telegram 9600 (2016): 1.
5. Balonek, Thomas J., ..., **Saiyang Zhang**, ..., et al. *Detection of optical outburst activity in the BL Lac object OT 081 (PKS 1749+096)*, The Astronomer's Telegram 9259 (2016).
6. Balonek, Thomas J., ..., **Saiyang Zhang**, ... et al. *A Dramatic Optical Flare and Microvariability in the Blazar 3C 454.3*. The Astronomer's Telegram 9178 (2016): 1.