ZESEN HUANG

Curriculum Vitae

Space and Astrophysical Plasma Physics · AI for Science: RL Environments, Agents and Benchmarks

Zesen Huang · Postdoctoral Researcher · Department of Earth, Planetary, and Space Sciences · UCLA
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RESEARCH INTERESTS

Alfvén-wave physics. The nonlinear physics of Alfvén waves in space and astrophysical plasmas: where they originate in the solar atmosphere, how they evolve as the solar wind expands, and what they are as nonlinear objects. Parker Solar Probe, Solar Orbiter and Ulysses observations, MHD theory, and three-dimensional simulations.

RL environments for science that grow with frontier AI. Research tasks cut from the public code and data of physics and astronomy, each with a program that checks the result, so that AI models learn to do research and are measured honestly; open-source research agents; and what passing a check actually shows.

The two connect: research supplies the environments with ground truth, and the environments show where AI can be trusted in research.

APPOINTMENTS

Jun 2024–present **Postdoctoral Researcher** · Department of Earth, Planetary, and Space Sciences, UCLA

Sep 2019–Jun 2024 **Graduate Student Researcher** · Department of Earth, Planetary, and Space Sciences, UCLA

Mar–May 2019
Jul–Sep 2018 **Visiting Undergraduate Researcher** · Space Sciences Laboratory, UC Berkeley

EDUCATION

2024 **Ph.D.**, Geophysics and Space Physics · University of California, Los Angeles
Dissertation: Tracing Alfvén Waves, Turbulence, and Gaussian Structures in the Upper Corona and Inner Heliosphere with in-situ Measurements, Statistical Analyses, and Modeling

2022 **M.S.**, Geophysics and Space Physics · University of California, Los Angeles

2019 **B.S. with Honors**, Geophysics (Space Physics) · School of Earth and Space Sciences, University of Science and Technology of China
Ranked 1st of 17 in the class

HONORS AND AWARDS

2025 **IAU PhD Prize**, Division E (Sun and Heliosphere), for 2024 · International Astronomical Union

2019 UCLA EPSS Department Fellowship

2019 Bachelor Honor Grade (top 4%) · University of Science and Technology of China

RESEARCH FUNDING AND COMPUTING

2026–2027 **Co-Investigator** · NASA ROSES-2024 Artificial Intelligence Applications in Heliophysics (AIAH), "Solar Wind Structures Identified Via Shannon Information Entropy," award 80NSSC26K0128 (PI M. Velli); $197,436. Wrote and led the proposal's science.

Jul–Oct 2026 **Principal Investigator** · NAIRR Pilot Start-Up project NAIRR260297, "GPU-Accelerated PLUTO MHD Simulations of Alfvén-Wave Collisions"; 2,000 GPU hours on SDSC Expanse

2024–2025 **Principal Investigator, computing allocation** · NSF ACCESS, "Gaussianization of Magnetic Magnitude in MHD Turbulence"

PHYSICS: ALFVÉN WAVES IN SPACE AND ASTROPHYSICAL PLASMAS

2025–present **The Alfvénon** · a three-dimensional solitary Alfvén wave with open field lines and nearly constant |B|, which propagates coherently for a finite time in ideal-MHD simulations (ApJL 1006, L20). Crossings of Alfvénons with embedded rotational discontinuities give switchback-like field reversals (arXiv:2512.12585). In progress: simulations of Alfvénon collisions.

2024–2026 **Where the fluctuations come from** · two-minute oscillations dominate the magnetic fluctuations near the Alfvén surface and match a two-minute coronal peak seen by SDO/AIA (ApJL 977, L12); in situ evidence of five-minute oscillations at 9.9 solar radii (ApJL 999, L4); the Gaussianity scalogram finds possible remnants of solar structures in Parker Solar Probe and Ulysses data (ApJL 973, L26).

2022–2025 **How they evolve as the wind expands** · spectra shallower than 1/f near the Sun evolve toward 1/f (ApJL 950, L8); there are two physically distinct types of 1/f range (ApJL 990, L34); total wave action is conserved across interacting modes in expanding-box MHD (ApJ 935, 60).

Collaborations Co-author of 14 refereed papers on switchbacks, intermittency, anisotropy, heating and turbulence, including Nature Astronomy 10, 1467 (2026).

AI FOR SCIENCE: ENVIRONMENTS, AGENTS AND SOFTWARE

Oct 2026–present **Lead, astronomy track, Agent Last Exam** · a benchmark of research-level tasks for AI agents. Building the astronomy part: a taxonomy of research directions across the astro-ph categories and space physics, open problems, and tasks with verifiable answers.

2026 **ScienceIDE** · co-first author; co-led the generation of scientific environments. Infrastructure that turns scientific codebases into executable environments for training and evaluating agents. github.com/aitofound/ScienceIDE

2026–present **LingTai** · lead contributor. Open-source (Apache-2.0) multi-agent framework for research: persistent specialized agents with memory and skills, working under human approval gates. github.com/Lingtai-AI/lingtai

2025–present **Gaussianity and Jensen–Shannon scalograms** · information-theoretic methods for non-stationary spacecraft time series (ApJL 973, L26), now being developed into open-source software under NASA AIAH funding.

2026 **Research tasks from simulation codes** · executable benchmark tasks cut from research codes (MHD and plasma simulations), with difficulty ladders and numerical and physical checks.

PUBLICATIONS

Complete list: ORCID 0000-0001-9570-5975 and NASA ADS. 7 first-author and 14 co-authored refereed articles.

Refereed articles, first author

1 2026 **Solitary Alfvén Waves**
Huang, Z., Velli, M., Shi, C., & Ding, Y.
The Astrophysical Journal Letters 1006, L20 · doi:10.3847/2041-8213/ae82f5

2 2026 **Evidence of 5 minute Oscillations from Parker Solar Probe**
Huang, Z., Velli, M., Panasenco, O., et al. (22 authors)
The Astrophysical Journal Letters 999, L4 · doi:10.3847/2041-8213/ae43ec

3 2025 **Two Types of 1/*f* Range in Solar Wind Turbulence**
Huang, Z., Velli, M., Chandran, B. D. G., et al. (7 authors)
The Astrophysical Journal Letters 990, L34 · doi:10.3847/2041-8213/adfa13

4 2024 **Dominance of 2 Minute Oscillations near the Alfvén Surface**
Huang, Z., Velli, M., Shi, C., et al. (14 authors)
The Astrophysical Journal Letters 977, L12 · doi:10.3847/2041-8213/ad9271

5 2024 **Solar Wind Structures from the Gaussianity of Magnetic Magnitude**
Huang, Z., Shi, C., Velli, M., et al. (12 authors)
The Astrophysical Journal Letters 973, L26 · doi:10.3847/2041-8213/ad72f1

6 2023 **New Observations of Solar Wind 1/*f* Turbulence Spectrum from Parker Solar Probe**
Huang, Z., Sioulas, N., Shi, C., et al. (26 authors)
The Astrophysical Journal Letters 950, L8 · doi:10.3847/2041-8213/acd7f2

7 2022 **Conservation of Total Wave Action in the Expanding Solar Wind**
Huang, Z., Shi, C., Sioulas, N., & Velli, M.
The Astrophysical Journal 935, 60 · doi:10.3847/1538-4357/ac74c5

Refereed articles, co-author

1 2026 **Non-adiabatic entropy increase in the solar wind governed by velocity spikes**
Hou, C., He, J., Rouillard, A. P., et al. (incl. **Huang, Z.**, 9th of 11)
Nature Astronomy 10, 1467-1477 · doi:10.1038/s41550-026-02923-5

2 2025 **Turbulence Properties of Corotating Interaction Regions at 1 au: A Comprehensive Superposed Epoch Analysis**
Ding, Y., Shi, C., Velli, M., **Huang, Z.**, & Sioulas, N.
The Astrophysical Journal 996, 89 · doi:10.3847/1538-4357/ae2025

3 2025 **The Temperature Anisotropy and Helium Abundance Features of Alfvénic Slow Solar Wind Observed by Parker Solar Probe, Helios, and Wind Missions**
Huang, J., Larson, D. E., Ervin, T., et al. (incl. **Huang, Z.**, 11th of 23)
The Astrophysical Journal Letters 986, L28 · doi:10.3847/2041-8213/ade0ac

4 2025 **Evolution of Magnetohydrodynamic Turbulence in the Expanding Solar Wind: Residual Energy and Intermittency**
Shi, C., Sioulas, N., **Huang, Z.**, Velli, M., Tenerani, A., & Réville, V.
The Astrophysical Journal 979, 152 · doi:10.3847/1538-4357/ad9f38

5 2024 **Metis Observation of the Onset of Fully Developed Turbulence in the Solar Corona**
Telloni, D., Sorriso-Valvo, L., Zank, G. P., et al. (incl. **Huang, Z.**, 16th of 73)
The Astrophysical Journal Letters 973, L48 · doi:10.3847/2041-8213/ad5a8c

6 2024 **Analytic Model and Magnetohydrodynamic Simulations of Three-dimensional Magnetic Switchbacks**
Shi, C., Velli, M., Toth, G., et al. (incl. **Huang, Z.**, 6th of 8)
The Astrophysical Journal Letters 964, L28 · doi:10.3847/2041-8213/ad335a

7 2023 **On the Evolution of the Anisotropic Scaling of Magnetohydrodynamic Turbulence in the Inner Heliosphere**
Sioulas, N., Velli, M., **Huang, Z.**, et al. (23 authors)
The Astrophysical Journal 951, 141 · doi:10.3847/1538-4357/acc658

8 2023 **The Evolution of the 1/*f* Range within a Single Fast-solar-wind Stream between 17.4 and 45.7 Solar Radii**
Davis, N., Chandran, B. D. G., Bowen, T. A., et al. (incl. **Huang, Z.**, 8th of 10)
The Astrophysical Journal 950, 154 · doi:10.3847/1538-4357/acd177

9 2023 **Proton and Electron Temperatures in the Solar Wind and Their Correlations with the Solar Wind Speed**
Shi, C., Velli, M., Lionello, R., et al. (incl. **Huang, Z.**, 5th of 11)
The Astrophysical Journal 944, 82 · doi:10.3847/1538-4357/acb341

10 2023 **Magnetic Field Spectral Evolution in the Inner Heliosphere**
Sioulas, N., **Huang, Z.**, Shi, C., et al. (27 authors)
The Astrophysical Journal Letters 943, L8 · doi:10.3847/2041-8213/acaeff

11 2022 **Patches of Magnetic Switchbacks and Their Origins**
Shi, C., Panasenco, O., Velli, M., et al. (incl. **Huang, Z.**, 7th of 21)
The Astrophysical Journal 934, 152 · doi:10.3847/1538-4357/ac7c11

12 2022 **Preferential Heating of Protons over Electrons from Coherent Structures during the First Perihelion of the Parker Solar Probe**
Sioulas, N., Shi, C., **Huang, Z.**, & Velli, M.
The Astrophysical Journal Letters 935, L29 · doi:10.3847/2041-8213/ac85de

13 2022 **Magnetic Field Intermittency in the Solar Wind: Parker Solar Probe and SolO Observations Ranging from the Alfvén Region up to 1 AU**
Sioulas, N., **Huang, Z.**, Velli, M., et al. (22 authors)
The Astrophysical Journal 934, 143 · doi:10.3847/1538-4357/ac7aa2

14 2022 **A Comparative Study of Magnetic Flux Ropes in the Nightside Induced Magnetosphere of Mars and Venus**
Hara, T., **Huang, Z.**, Mitchell, D. L., et al. (7 authors)
Journal of Geophysical Research: Space Physics 127, e2021JA029867 · doi:10.1029/2021ja029867

Preprints

1 2026 **ScienceIDE: Turning World's Scientific Codebase into Agent Learnable Environments**
Geng, H.*, **Huang, Z.***, Li, H., et al. (45 authors; * equal contribution)
Preprint · arXiv:2609.19134

2 2026 **Spherically Polarized Alfvén Waves and the Gosling Boost**
Ding, Y., Velli, M., **Huang, Z.**, et al. (9 authors)
Preprint · arXiv:2608.05091

3 2026 **A Magneto-Convective Origin for Solar-Wind Alfvénic Fluctuations**
Morton, R., **Huang, Z.**, Schad, T., & Velli, M.
Preprint (Research Square) · doi:10.21203/rs.3.rs-9657704/v1

4 2025 **What are Switchbacks?**
Huang, Z., Velli, M., & Ding, Y.
Preprint · arXiv:2512.12585

5 2023 **In situ Remnants of Solar Surface Structures from Jensen-Shannon Scalogram**
Huang, Z., et al. (12 authors)
Preprint (Research Square) · doi:10.21203/rs.3.rs-3597425/v1

Workshop papers and chapters

1 2026 **What Git Does Not Record: Provenance Legibility in Two AI-Assisted Research Repositories**
Wu, K., **Huang, Z.**, & Geng, H.
NeurIPS 2026 Workshop on AI-Native Academia (accepted) · arXiv:2610.28655

2 2026 **Probing the Solar Corona and the Solar Wind Using Angular Broadening Observations with the SKA**
Zhang, P., Morgan, J., Oberoi, D., et al. (incl. **Huang, Z.**, 7th of 12)
In *Advancing Astrophysics with the SKA II* · arXiv:2603.25421

TALKS

Seminars

Oct 7, 2026	UNH Space Science Center seminar · "New Physics of Alfvén Waves: Parker Solar Probe and Agentic, Wish-Driven Research"
Oct 6, 2026	Dartmouth College, Space and Plasma Seminar · "New Physics of Alfvén Waves Discovered by Parker Solar Probe"
Oct 1, 2026	Boston University, Center for Space Physics seminar · "New Physics of Alfvén Waves Discovered by Parker Solar Probe"
Aug 10, 2026	Center for Astrophysics | Harvard & Smithsonian, AstroAI lunch seminar · "AI Agents as Genies: Can Wish-Driven Research Really Work?"
Mar 26, 2026	Parker Solar Probe Theory telecon · "Solitary Alfvén Waves"
Feb 6, 2026	Parker Solar Probe Science Working Group telecon · "New Physics of Alfvén Waves from Parker Solar Probe"
Sep 2025	Parker Solar Probe Science Working Group monthly seminar (invited) · "In situ Evidence of 5-minute Oscillations from Parker Solar Probe"
Feb 2025	UCLA Space Physics Seminar (invited) · "1/f Range in Solar Wind Turbulence: Insight from Parker Solar Probe"
Jul 2024	Parker Solar Probe Theory telecon · "3-Minute Oscillations in the Upper Corona: Evidence from Parker Solar Probe"

Conferences

Jun 2026	2026 AstroAI Workshop, Center for Astrophysics (contributed talk) · "Democratizing Astrophysical Research with AI Agents: Lessons from Heliophysics"
May 2025	Parker Four Conference · "Two Types of 1/f Range in Solar Wind Turbulence"
Apr 2024	Triennial Earth–Sun Summit (TESS), Dallas · "Prediction and Verification of Parker Solar Probe Encounter 12 Solar Wind Sources with Jensen–Shannon Scalogram"
Apr 2024	EclipseSA, San Antonio (poster) · "Solar Wind Turbulence, Leakage from Photosphere 5-min Oscillations?"
Dec 2023	AGU Fall Meeting, San Francisco (poster) · "Natural Contextualization of Solar Wind Time Series with Jensen–Shannon Scalogram"
Oct 2023	Parker Heliophysics Scholars, 6th meeting · "In situ Remnants of Solar Surface Structures from Parker Solar Probe and Ulysses"
Jun 2023	Solar Wind 16, Monterey · "New Observations of Solar Wind 1/f Turbulence Spectrum from Parker Solar Probe"

Dec 2022 AGU Fall Meeting, Chicago · “Evolution of Lower Frequency Breaks of Alfvénic Turbulence in the Inner Heliosphere, Observed by Parker Solar Probe and Solar Orbiter”

Jul 2022 44th COSPAR Scientific Assembly, Athens · “Conservation of Total Wave Action and Magnetosonic Resonance Broadening in Expanding Solar Wind”

TEACHING AND MENTORING

Fall 2026 **Organizer and lecturer, AI in Research series** · UCLA EPSS 254 / SPHINX. Weekly sessions on using and evaluating AI agents in research; students build benchmark tasks. class.xhelio.ai

Current **Co-advisor**, Yuliang Ding, PhD student, UCLA · nonlinear Alfvén waves (arXiv:2608.05091)

2026–2027 **Research mentor**, high-school student, Honors Research in Science, Marlborough School · two-minute oscillations in Parker Solar Probe data

2016 **Teaching Assistant**, electromagnetism · University of Science and Technology of China

SERVICE AND OUTREACH

2023–present **Referee**, 14 manuscripts and 20 review rounds for ten journals, including ApJ, ApJL, A&A, JGR: Space Physics, Geophysical Research Letters, Solar Physics and Scientific Reports

2026 **Reviewer**, AgentSkills 2026 workshop (2 papers)

2022–2024 **Judge**, AGU Outstanding Student Presentation Awards

2022, 2023 **Volunteer**, UCLA Explore Your Universe (booth “Our Magnetic Sun”)

2018–2020 **Chief Editor**, Dr. Stone Student Science Outreach Club

SKILLS

Computing Python, Fortran, IDL, Mathematica; GPU and HPC MHD simulation; spacecraft data; AI agents

Languages English (fluent); Mandarin and Cantonese (native)