Tianrui (Dennis) Wu

Curriculum Vitæ

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Education

University of Arizona *Tucson, Arizona, USA* Jan. 2026 – May 2027

- Bachelor of Science in Physics; minor in Mathematics; expected graduation by May 2027
- GPA: 3.89/4.00
- Advisors: Prof. Tim Eifler, Arizona Cosmology Lab; Prof. CK Chan, EHT Collaboration
- Dean's List; Global Wildcat Scholarship ($10,000/year merit award)
- Selected coursework: Computational Physics; Quantum Theory II; Methods of Experimental Physics I
- In progress (Fall 2026): Advanced Applied Mathematics; Electricity and Magnetism II; Digital Electronic Techniques

Duke University *Durham, North Carolina, USA* Aug. 2021 – Dec. 2024

- Bachelor of Science in Physics and Mathematics; minor in Computer Science; *degree not conferred (transferred to Arizona)*
- GPA: 3.92/4.00; Physics GPA: 4.00/4.00
- Advisors: Prof. Michael A. Troxel and Prof. Daniel Scolnic
- Dean's List with Distinction, Fall 2021 to Fall 2024
- Graduate coursework: General Relativity (PHYSICS 622); Introduction to Cosmology (PHYSICS 555); Stellar Astrophysics (PHYSICS 556); Representation Theory (PHYSICS 603); Algebraic Structures I (MATH 501); Real Analysis I (MATH 531); Theory and Algorithms of Machine Learning (COMPSCI 671D)

Publications

Published

[1] OpenUniverse et al. (including **T. Wu**). "OpenUniverse2024: A Shared, Simulated View of the Sky for the Next Generation of Cosmological Surveys." *MNRAS* **544**(4), 3799–3823 (2025). doi:10.1093/mnras/staf1833.

[2] Riess, A. G., Scolnic, D., et al. (including **T. Wu**). "JWST Validates HST Distance Measurements: Selection of Supernova Subsample Explains Differences in JWST Estimates of Local H_0." *ApJ* **977**, 120 (2024). arXiv:2408.11770.

In Preparation

[3] **Wu, T.**, Paillas, E., & Eifler, T. "BAO Reconstruction in the Presence of Photometric Redshift Uncertainty." Manuscript in preparation; arXiv submission expected Dec. 2026.

Research Experience

Characterizing Photometric BAO Reconstruction *Tucson, AZ*

Arizona Cosmology Lab, Steward Observatory, University of Arizona Feb. 2026 – Present

Project: *BAO Reconstruction in the Presence of Photometric Redshift Uncertainty (first-author paper; sole analyst)*

Advisor: Prof. Tim Eifler

Goal: Test when standard reconstruction still improves BAO distances given SPHEREx-like redshift errors and densities.

Results:

- Developed `photorecon`, a Python package for transverse BAO reconstruction on photometric galaxy samples that mirrors the community `pyrecon` interface; now being tested for SPHEREx at low redshift.
- Found and corrected a systematic bias in the MCMC pipeline by cross-validating two covariance estimators over a 250-cell sensitivity grid, cutting the bias sixfold.
- Across 25 DESI AbacusSummit mocks, combining four redshift-precision classes per bin raised the 2D BAO figure of merit by 26–271% after reconstruction and recovered the input distances within 1.3σ.
- Identified the operating range of standard reconstruction, $\sigma_z/(1+z) \lesssim 0.003$ and shot noise below $\sim 2.5\times$ the BAO-scale clustering power, to guide SPHEREx sample selection.

Building a Neural Network to Predict Window Functions for SPHEREx *Pasadena, CA*

SPHEREx Team, Summer Undergraduate Research Fellowship (SURF), Caltech Jun. 2024 – Aug. 2024

Project: *Predicting Power-Spectrum Window Functions with Neural Networks*

Advisor: Dr. Olivier Doré

Goal: Remove instrument window-function effects from galaxy power spectra with a fast neural-network model, improving the analysis pathway for local primordial non-Gaussianity $f_{\mathrm{NL}}^{\mathrm{loc}}$.

Results:
- Built a ResUNet convolutional neural network in PyTorch with sub-percent prediction error on validation data.
- Owned the full pipeline: lognormal mock catalogs with realistic SPHEREx survey masks, distributed training on Linux HPC, and validation against analytic baselines.
- Delivered a proposal, two interim reports, a final presentation, and a final report to the SPHEREx faculty committee.

Building Roman and Rubin Weak-Lensing Synergies *Durham, NC*

Cosmology Group, Department of Physics, Duke University May 2022 – Dec. 2024

Project: *Weak-Lensing Cosmology with Survey Synergies*

Advisor: Prof. Michael A. Troxel

Goal: Test how joint analysis of Roman Space Telescope and Rubin Observatory data, and ground–space survey synergies, can improve photometric-redshift calibration and cosmological constraints.

Results:
- Engineered a Python pipeline for joint statistical analysis of 120 TB of Roman and Rubin simulations, building two-point correlation functions and running MCMC-based Bayesian inference on cosmological parameters.
- New mode-based calibration strategies raised the Figure of Merit by 20% and tightened constraints on cosmic homogeneity; contributed simulation and analysis work to OpenUniverse2024 (MNRAS, 2025).

EHT Research: Astronomical Software Engineering Internship *Tucson, AZ*

TIMESTEP Program, Steward Observatory, University of Arizona Aug. 2026 – Present

Project: *Hallmark: Data Management for Event Horizon Telescope Simulations and Beyond*

Advisor: Dr. Chi-kwan Chan

Goal: Make large simulation libraries easy to search and reuse by turning their file paths into structured parameters, then generalize the tool beyond the EHT to any collaboration or data source.

Results:
- Developed Hallmark, an open-source Python package that decodes simulation file paths into parameter data frames.
- Added Git-based data version control and parameter-driven downloads of public-data subsets such as DESI.

Calibrating the Distance Ladder Using Stars *Durham, NC*

Cosmology Group, Department of Physics, Duke University Sep. 2023 – Aug. 2024

Project: *Distance-Ladder Calibration with Synthetic Stellar Populations*

Advisor: Prof. Daniel Scolnic

Goal: Build a common framework for comparing distance-calibration methods across teams, and test the JWST and HST distances behind local H_0.

Results:
- Developed a Python pipeline for synthetic stellar catalogs and systematic feature extraction from Hertzsprung–Russell diagrams, unifying new calibration methods for cross-team comparison.
- Compared JWST distance measurements across the literature and quantified galaxy–dust correlations in SDSS data with SQL and Python; contributed to Riess et al. (ApJ, 2024).

Predicting Wetland Carbon Emissions *Durham, NC*

Data+ Program, Duke University May 2023 – Aug. 2023

Project: *Quantifying Wetland Carbon Emissions in the Southeastern United States*

Advisor: Prof. Wenhong Li

Goal: Estimate wetland carbon emissions across the Southeastern United States from incomplete climate records.

Results:
- Led a four-person team; applied climatology-based adaptive missing-value imputation and grid-searched a random-forest model while mentoring teammates on SVM and multilayer-perceptron models.
- Delivered a layered R Shiny analytics application and a final research presentation.

Research Software

`cosmock`: Mock Weak-Lensing Map Generation *github.com/ivan96eb/cosmock*
Co-developer; Python 2026

- Open-source package that generates tomographic weak-lensing convergence maps from input maps and angular power spectra using point-transformed Gaussian fields.
- Implemented harmonic-space Gaussian sampling, Cholesky-based cross-bin correlations, and HEALPix map synthesis; applied nonlinear transformations and pixel-window filtering to generate convergence maps.
- Authored API documentation covering array shapes, transformation orders, spectrum conversion, and the fitting-to-generation workflow; clarified attribution of the underlying method.

`hallmark`: Reproducible Data Management for Simulation Libraries *github.com/lanisrc/hallmark*
Contributor; Python 2026

- Open-source package motivated by Event Horizon Telescope calibration and simulation workflows.
- Worked on metadata extraction that decodes parameters in file paths into filterable data frames (custom parsing rules via YAML), Git-based dataset versioning, and parameter-driven subset downloads.

Awards and Fellowships

First Place, U.S. Physicists' Tournament 2026
Team competition in open-ended physics investigation, presentation, and scientific debate

Global Wildcat Scholarship, University of Arizona 2026
$10,000/year merit scholarship for international transfer students

Faculty Scholars Finalist, Duke University 2024
Sole physics nominee; among Duke's highest undergraduate honors

Jocelyn Bell Burnell Outstanding Leadership Scholarship, Society of Physics Students 2024
$6,000; sole recipient nationwide

Inductee, Sigma Pi Sigma National Physics Honor Society 2024
Membership awarded for academic distinction in physics

Outstanding Chapter Award, Society of Physics Students 2023
Awarded to the Duke Chapter for exceptional performance of chapter activities and academic performance

Third Grand Award, Physics and Astronomy, Regeneron International Science and Engineering Fair 2021
$1,000 award in the Physics and Astronomy category

Top Gold Medalist, British Physics Olympiad 2021
Ranked in the national top ten

Dean's List with Distinction and Full-Time Dean's List 2021 – 2026
Duke University (Fall 2021, Spring 2023, Fall 2023, Fall 2024) and University of Arizona (Spring 2026)

Talks and Presentations

BAO Reconstruction with Photometric Redshift Smearing Oct. 2026
TACOS Talk, Arizona Cosmology Lab, Steward Observatory, University of Arizona; Steward-wide audience

BAO Reconstruction with Photometric Redshift Smearing Oct. 2026
Steward Astronomy Symposium, University of Arizona

BAO Measurements, Cosmology Session Oct. 2026
SPHEREx Science Team Meeting

BAO Measurements, Cosmology Session Jun. 2026
SPHEREx Science Team Meeting (Face-to-Face E4), IPAC, Caltech

BAO analysis segment of the SPHEREx team colloquium Apr. 2026
SO/NSF NOIRLab Joint Colloquium, Steward Observatory, University of Arizona

Predicting Power Spectrum Window Function with Neural Networks Aug. 2024
SURF Final Presentation, SPHEREx Team, Caltech

Quantifying Wetland Carbon Emissions in the Southeastern United States Aug. 2023
Data+ Final Presentation, Duke University

Teaching

Private Physics and Mathematics Tutor
PalmDrive Academy Feb. 2025 – Dec. 2025

Taught high-school physics and mathematics for 20 hours/week; guided more than 50 students to the top AP exam score of 5.
Courses taught: AP Physics; AP Calculus; AP Math; Cambridge A-Level Physics

Assistant *Durham, NC*
Department of Mathematics, Duke University Aug. 2022 – Apr. 2024

Assisted 40+ students weekly across two three-hour Help Room shifts and led two one-hour SAGE discussion sections each week; rated "Excellent" (30/30) by supervisors and peers in the 2023 and 2024 reviews.
Courses: MATH 212: Multivariable Calculus; MATH 221: Linear Algebra; MATH 340: Advanced Introduction to Probability

Professional Experience

Quantitative Researcher and Systematic Trader *Remote*
Origin Capital Aug. 2025 – Present

Financial time-series modeling; full-time Aug. 2025 – May 2026; part-time May 2026 – Present

- Developed an LSTM forecasting pipeline for financial time series with phase-space representations and 200+ features sampled at multiple time scales; tracked experiments, model versions, and deployed performance with MLflow.
- Built vectorized and event-level simulation engines to compare model predictions against held-out data; incorporated temporal structure and transaction costs into evaluation of deployed financial models.
- Developed continuous data ingestion and monitoring across three exchanges, with automated diagnostics for model behavior, variability, and exposure; investigated changes in model performance under changing market conditions.
- Led a two-person research team, mentored junior researchers, and reviewed methodology and code before deployment.

Applied technologies: Python (PyTorch, MLflow, Polars, pandas, NumPy), REST/WebSocket APIs, Linux, Git

Quantitative Research Intern *Shenzhen, China*
InsightCheck Investments Feb. 2025 – Aug. 2025

Statistical modeling and high-performance analysis of financial data

- Applied principal-component analysis, mean-reversion models, and covariance estimation to high-dimensional financial time series; evaluated 62+ intraday predictors using correlation-based validation and simulation-based evaluation.
- Independently developed an event-level data reconstruction engine, prototyping in Python and migrating to C++; processed one trading day of full-universe A-share data in approximately one second.
- Built a Dask-based distributed simulation framework that reduced model-evaluation time tenfold to approximately 15 minutes.

Applied technologies: Python (Polars, Dask), C++, SQL, Linux, Git

Leadership and Outreach

Peer Mentor for Incoming Freshmen *Tucson, AZ*
University of Arizona Fall 2026 – Present

Volunteered to mentor incoming first-year students through their transition to university study.

Founder and President *Durham, NC*

Stargazing Devils, Duke's student astronomy club Sep. 2021 – Dec. 2024

- Founded Duke's first astronomy club and organized weekly observatory open houses with 100+ attendees, three comet events, four meteor-shower events, and three eclipse events; served as a NASA Partner Eclipse Ambassador.
- Secured funding for 14 students to attend the 2023 and 2024 solar eclipses, organized a campus eclipse watch party for 300+ participants, and led 20+ astrophotography events using the Skynet platform.

President (2024) and Co-President (2023) *Durham, NC*

Society of Physics Students, Duke chapter of the national physics student society Jun. 2022 – Dec. 2024

- Revived the chapter after the pandemic through four research panels, six student–faculty seminars, three laboratory tours, MATLAB/LaTeX workshops, graduate-school panels, and a women's mentorship program.
- Organized the 2023 SPS Zone 5 meeting for 100+ participants; the chapter received the 2023 Outstanding Chapter Award.

Student Ambassador *Remote*

American Physical Society, national student ambassador program Jun. 2022 – May 2024

- Recruited APS members; organized physics study sessions, manuscript workshops, and publication events; served as Technology Chair for the Physics Undergraduates Learning and Sharing Experiences webinar series.
- Attended the 2023 and 2024 APS Leadership Meetings and advocated on physics-community priorities during U.S. Congressional Visits Day.

Senior Editor and Peer Reviewer *Durham, NC*

Duke Vertices, Duke's undergraduate science journal Sep. 2021 – Aug. 2024

Reviewed two STEM manuscripts per month and implemented a synopsis system for general audiences that increased website traffic by 210%; invited by the editor-in-chief to join the executive team.

Skills and Interests

Programming: Python (expert), Rust, C/C++, Java, R, SQL/PostgreSQL, MATLAB, Julia, JavaScript, and LaTeX

Machine Learning and Data: PyTorch, MLflow, Polars, pandas, NumPy, Numba, Dask, SciPy, astropy, Matplotlib; ResUNet/CNN and LSTM architectures; random forests, support-vector machines, multilayer perceptrons, feature engineering, selection, and grid-search optimization

Statistical and Scientific Methods: Bayesian inference, MCMC, Monte Carlo simulation, statistical modeling, sensitivity analysis, covariance estimation, two-point correlation functions, time-series analysis, out-of-sample validation, distributed model evaluation, Linux HPC, Git, REST/WebSocket APIs, and Grafana monitoring

Domain Knowledge: Observational cosmology (BAO, weak lensing, power spectra, photometric-redshift calibration); survey simulations, scientific data management, and machine learning for cosmological analysis

Research Tools: Scientific writing in LaTeX, manuscript review, literature synthesis, research presentations, and scientific visualization; AI-agent-assisted coding and research workflows, reusable task instructions, source traceability, and review of generated outputs

Languages: English (fluent); Mandarin Chinese (native)

Interests: Poker, competitive GeoGuessr, tabletop wargaming, strategy board games, chaos theory, forecasting, astrophotography, cosmology, science fiction