Zezheng Zhu

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EDUCATION

Columbia University, New York, NY 10027, USA

- Ph.D. in Applied Physics — 2023-09 – Present
  - Advisor: Prof. Nanfang Yu
- M.S. in Applied Physics — 2025-02
  - Earned en route to the Ph.D.
- B.S. in Applied Physics — 2023-05
  - Advisor: Prof. Nanfang Yu

Denison University, Granville, OH 43023, USA

- B.S. in Physics — transferred 2021-05
  - Advisor: Prof. C. Wesley Walter
- B.A. in Mathematics — transferred 2021-05
  - Advisor: Prof. Matthew P. Neal

SKILLS

Cleanroom Nanofabrication

- 3000+ hours of cleanroom experience in process development and device fabrication.
- Thin-film deposition and processing: PECVD, ALD, electron-beam evaporation, sputtering.
- Lithography: electron-beam lithography, photolithography, resist coating, exposure, development, lift-off.
- Nanostructure etching and plasma processing: ICP etching, RIE, plasma ashing.
- Material and device characterization: ellipsometry, profilometry, AFM, and SEM imaging.

Nanophotonics Device Design and Simulation

- End-to-end metasurface design workflow: function specification, target phase/amplitude/polarization profile generation, meta-atom material and geometry selection, and metasurface library construction.
- Full-wave and system-level optical simulation using Lumerical, Zemax, and COMSOL.
- Fabrication layout generation from optimized metasurface to photolithography/electron-beam lithography, including Beamer-based proximity-effect correction.
- Waveguide and integrated photonics design: mode analysis, coupling structures, propagation engineering.
- Photonic crystal and resonant nanophotonic device design: photonic crystal slabs, quasi-BIC modes, leaky-wave devices, band/mode analysis.

Scientific Computing and Programming

- Optimization algorithms for metasurface design and inverse-design workflows implemented in MATLAB and Python.
- Python and MATLAB coding for scientific computing, data analysis, numerical simulation, visualization, and automated design-space exploration.
- Mathematica-based symbolic and numerical scientific computing for analytical modeling and theoretical calculations.
- LabVIEW-based hardware control, measurement automation, data acquisition, and experimental workflow development.
- Foundational working knowledge of C++ and R.

Other

- 3D modeling and mechanical-part design.
- 3D printing workflow: CAD-to-print preparation, printer operation, and basic post-processing for rapid prototyping.
- Hands-on experience with machine-shop and woodworking tools.

PUBLICATIONS

- "Trapping of single atoms in metasurface optical tweezer arrays," *Nature*, 2026-01.
  A. Holman, Y. Xu, X. Sun, J. Wu, M. Wang, Z. Zhu, B. Seo, N. Yu, and S. Will
- "Scalable Neutral-Atom Tweezer Arrays Based on TiO2 Holographic Metasurfaces," *CLEO 2026*, 2026.
  Z. Zhu, Y. Xu, A. Holman, J. Wu, X. Sun, M. Wang, B. Seo, S. Will, and N. Yu
- "Metasurface-Based Monocular Metric Depth Imaging," *CLEO 2026*, 2026.
  J. Wu, B. Li, Y. Xu, Y. Zhang, Z. Zhu, Q. Sun, and N. Yu
- "Metasurface-Based Millimeter-Wave Neural Network for 3D Facial Verification," *CLEO 2026*, 2026.
  C.-C. Tsai, J. Kim, A. N. Willner, R. Landsberger, Z. Zhu, J. Wu, Z. Wu, Z. Yu, and N. Yu
- "A Mid-Infrared Platform Based on Strontium Tweezer Arrays," *arXiv preprint arXiv:2606.02560*, 2026-06.
  A. Holman, X. Sun, B. Seo, J. Corn, Z. Zhu, Y. Xu, J. Wu, N. Yu, D. Filin, M. Safronova, and S. Will

- "Mid-Infrared Control of ^{88}Sr in Magic-Wavelength Optical Tweezers," *APS DAMOP 2026*, 2026-06.
  A. Holman, X. Sun, Z. Zhu, J. Corn, H. Dhonte, D. Filin, M. S. Safronova, N. Yu, and S. Will
- "CMOS-based deep brain imager with a monolithically integrated metasurface," *Metamaterials, Metadevices, and Metasystems 2025*, 2025-09.
  S. Yilmaz, J. Wu, H. Yin, J. Choi, Y. Gilhotra, V. Arslan, Y. Xu, T. Qu, Z. Zhu, C.-C. Tsai, N. Yu, and K. L. Shepard
- "Nano-Optics for Depth Sensing," *ACM SIGGRAPH 2025 Emerging Technologies*, 2025-08.
  Y. Xu, B. Li, J. Wu, Z. Zhu, Y. Zhang, N. Yu, and Q. Sun
- "Physically Grounded Monocular Depth via Nanophotonic Wavefront Prompting," *arXiv preprint arXiv:2503.15770*, 2025.
  B. Li, J. Wu, Y. Xu, Z. Zhu, Y. Zhang, K. Chen, Y. Liang, N. Yu, and Q. Sun
- "Ultracompact metasurface-based shank for deep-tissue neuron localization," *CLEO 2025*, 2025.
  J. Wu, S. Yilmaz, Y. Xu, T. Qu, Z. Zhu, C.-C. Tsai, K. Shepard, and N. Yu
- "Quasi-Bound States in the Continuum and Enhanced Light-Matter Interactions in GaN/InGaN Epitaxial Metasurfaces," *Frontiers in Optics + Laser Science 2024*, 2024.
  Y. Xu, J. Liu, A. Singh, C.-C. Tsai, S. C. Malek, W. J. Shin, J. Wu, Z. Zhu, D. Liu, N. Yu, Z. Mi, and M. Soltani

RESEARCH EXPERIENCE

Columbia University, Nanfang Yu Lab — Graduate Research Assistant | 2023 – Present

- Design, Nanofabrication, and Process Development of Metasurface Optical Tweezer Arrays
  - Related publications: "Trapping of single atoms in metasurface optical tweezer arrays," *Nature*, 2026; "Scalable Neutral-Atom Tweezer Arrays Based on TiO_2 Holographic Metasurfaces," *CLEO 2026*, 2026.
  - Fabricated SiN metasurfaces for optical-tweezer array generation used in single-atom trapping experiments.
  - Developed and executed a TiO_2 metasurface fabrication process for scalable tweezer-array devices.
  - Designing next-generation atomic-tweezer metasurfaces for improved device performance and integration.
- Near-Infrared Wavefront Shaping Through Biological Scattering Media
  - Current project; details available upon request.
  - Performed early-stage simulations to evaluate whether near-infrared light can be focused through strongly scattering biological media while retaining usable intensity.
  - Developed vectorial light-transport simulation code for propagation from electrically driven optical sources through scattering media while preserving polarization and phase information.
  - Designed focusing optimization algorithms for wavefront control through scattering media and high-NA optical-mode delivery.
  - Designed and fabricated project-specific metasurfaces; performed optical-table characterization, device integration, and experimental validation.
- Visible-Wavelength Leaky-Wave Metasurfaces for On-Chip Free-Space Optics
  - Relevant work: "Leaky-wave metasurfaces for integrated photonics," *Nature Nanotechnology*, 2023.
  - Designed and fabricated visible-wavelength leaky-wave metasurface devices based on a platform originally demonstrated at near-infrared wavelengths.
  - Exploring visible-wavelength leaky-wave metasurfaces for integrated free-space beam shaping and atomic-tweezer applications.
  - Current project: developing tunable leaky-wave metasurface versions; details available upon request.
- Metasurface Fabrication and Optical Characterization for Nano-3D Depth Imaging
  - Related publications: "Nano-Optics for Depth Sensing," *ACM SIGGRAPH 2025 Emerging Technologies*, 2025-08; "Physically Grounded Monocular Depth via Nanophotonic Wavefront Prompting," *arXiv preprint arXiv:2503.15770*, 2025; "Metasurface-Based Monocular Metric Depth Imaging," *CLEO 2026*, 2026.
  - Developed cleanroom fabrication recipes and fabricated TiO_2 metasurfaces for metasurface-based depth imaging and compact monocular depth-sensing demonstrations.
  - Built and operated optical-table setups for device alignment, polarization-resolved imaging, optical-response measurement, and depth-sensing validation.
- Metasurface Fabrication on Ultra-Thin Glass Substrates for Deep-Brain Imaging Devices
  - Related publications: "CMOS-based deep brain imager with a monolithically integrated metasurface," *Metamaterials, Metadevices, and Metasystems 2025*, 2025-09; "Ultracompact metasurface-based shank for deep-tissue neuron localization," *CLEO 2025*, 2025.
  - Solved fabrication challenges for metasurfaces on ultra-thin glass substrates thinner than 30 μm for deep-brain imaging and neuron-localization devices.
  - Developed substrate pretreatment and process-compatible handling workflows for fragile ultra-thin glass, including cleaning, surface preparation, mounting, and release.
  - Fabricated metasurface devices through thin-film preparation, lithography, etching, and post-processing, producing devices for integration with deep-tissue imaging platforms.

Columbia University, Nanfang Yu Lab — Undergraduate Research Assistant | 2021 – 2023

- Optical Characterization and LabVIEW Automation for GaN/InGaN Metasurfaces and Photonic Crystals
  - Related publication: "Quasi-Bound States in the Continuum and Enhanced Light-Matter Interactions in GaN/InGaN Epitaxial Metasurfaces," *Frontiers in Optics + Laser Science 2024*, 2024.
  - Characterized GaN/InGaN epitaxial metasurfaces and photonic-crystal devices, including quasi-BIC optical responses, angular dispersion, and resonant-mode behavior.
  - Developed LabVIEW automation for motorized stages, spectrometer/camera control, synchronized acquisition, and repeatable measurement routines.
  - Built the optical characterization setup and carried out optical-table measurements for metasurface and photonic-crystal device validation.

Denison University Undergraduate Research Assistant | 2020 – 2021

- Automated Laser-Energy Control for Precision Negative-Ion Spectroscopy
  - Relevant work: "Observation of an Electric Quadrupole Transition in a Negative Ion: Experiment and Theory," *Physical Review Letters*, 2021.
  - Designed and implemented a motorized polarization-based laser-energy-control module for a precision negative-ion spectroscopy platform.
  - Integrated piezo-motor actuation, control electronics, and polarization optics with the existing ion-beam apparatus.
  - Developed LabVIEW routines for device control, data acquisition, and reproducible laser-energy tuning during spectroscopy measurements.
- Detector-Sensitivity Modeling for Ultra-High-Energy Neutrino Source Interpretation with ARA
  - Relevant work: "Constraints on the diffuse flux of ultra-high-energy neutrinos from four years of Askaryan Radio Array data in two stations," *Physical Review D*, 2020.
  - Analyzed the interpretability of ultra-high-energy neutrino source models under ARA detector sensitivity, exposure, and polar-ice radio-propagation constraints.
  - Built and optimized ROOT/C++/bash simulation workflows on the Ohio Supercomputer Center for model propagation, detector-response studies, and event-rate analysis.
  - Prepared the research proposal, synthesized source-model and detector literature, and analyzed simulation and detection datasets for sensitivity-driven model assessment.

AWARDS & SCHOLARSHIPS

- Graduated *cum laude*, Columbia University 2023-05
  Latin honor awarded upon completion of the B.S. in Applied Physics.
- Dean's List, Columbia University 2021 – 2022
- Ronald R. Winters Award, Denison University 2021-05
  For excellence in the field of physics.
- Anderson Summer Research Scholarship, Denison University Summer 2020
- Member of Sigma Pi Sigma, Physics Honorary Society, Denison University 2020-04
- Dean's List, Denison University 2018 – 2021
- Provincial Prize, Chinese Physics Olympiad, Senior Division 2017

LANGUAGES

- English: Full professional proficiency.
- Mandarin Chinese: Native proficiency.
- Japanese: Elementary proficiency.

INTERESTS

Wildlife, landscape, and portrait photography; commercial videography; backpacking; kayaking; alpine skiing; automotive repair and modification.