AMARNATH S. PATEL

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Research interests: computational statistical physics and inference — forward models of physical systems, simulation-based inverse problems, uncertainty quantification, and the statistical physics of learning.

EDUCATION

University of Central Florida **Undergraduate Student** **4.00 GPA**

B.S. in Physics (Optics & Lasers) and Mathematics, Computer Science Minor (43 credit hours) August 2025 – Present

Florida Atlantic University **3.66 GPA**

University coursework completed via FAU High School, ages 14–18 (108 credit hours; 3 more at Palm Beach State College) August 2021 – May 2025

RESEARCH EXPERIENCE

UCF Physics Department — Computational Soft Matter, Undergraduate Researcher Fall 2026 – Present

Supervisor: Dr. Aniket Bhattacharya

- Developing a dressed (distorted-wave) Born theory of light scattering from core–corona particles — a dense core with a soft polymer brush, the regime where plain Born ignores the core's field, layered Mie needs a round shell, and DDA is too slow to run over many MD frames. The core is treated exactly and each brush element to first order, driven by the core's near field and radiating back through it by reciprocity. The theory reduces to the Debye equation at zero core contrast.
- Validated against exact solutions: coated-sphere Mie for round shells (dressed $<1\%$ error vs. 5–60% for plain Born, scaling with shell contrast as a first-order theory should) and an exact coupled-dipole model of asymmetric Janus coronas, orientation-averaged (0.1–0.3% vs. 7–20%). Showed that at leading order the orientation-averaged signal sees only the radial corona profile (Janus/full = 0.49–0.50), and that depolarized scattering arises only through the core's field.
- Built point-coordinate Debye-equation scattering code and accompanying theory notes for computing $I(q)$ from molecular-dynamics trajectories (form factors, Guinier/Porod/Kratky analysis, polydispersity, Percus–Yevick structure factors), and mapped where Rayleigh, Born, anomalous-diffraction and geometric-optics approximations fail against exact Mie theory.

UCF Astrophotonics Lab, CREOL — Undergraduate Researcher August 2025 – Present

Supervisor: Dr. Stephen Eikenberry

- Recovering the wavelength-dependent complex transfer matrix of a photonic lantern — an inverse problem from interferograms to modal amplitudes and phases — by off-axis digital holography, extending Dobias et al., *Opt. Express* **34**(9), 17217 (2026). Each input port across the C-band (1525–1575 nm) yields one row of the matrix.
- Implemented the reconstruction: FFT sideband isolation and demodulation, then joint numerical optimization of mode-field diameter, defocus phase and field position, and decomposition onto the LP basis. Reconstruction fidelity $|\langle E_{\mathrm{rec}}, E_{\mathrm{sim}}\rangle|^2$ of 97.2 ± 0.5% on a 51-frame single-port C-band sweep and 92.7 ± 1.7% on a 7-port sweep acquired by Rumana Akhter with this software; reproduced the lab's prior 19-port analysis (96.68 ± 1.58% over 969 frames, vs. 96.89% from the original run) in 65 s with 8 processes. Diagnosed where a single-axis 8-mode basis stops describing the device.
- Automated the four-instrument acquisition chain (tunable laser, InGaAs camera, fiber switch, motorized polarization control) with in-loop polarization optimization and saturation rejection, turning days of manual bench time into one unattended all-port × C-band sweep.
- Own the telescope-node software for PolyOculus, a networked array of 8 telescopes on Jetson Nanos: brought the nodes up on mainline Linux, wrote centroid-based autoguiding (simulated tracking error 3.01″ ⟶ 0.29″ RMS) and closed-loop fast-steering-mirror control holding a laser spot to 0.2 px.

UCF Physics Department — Undergraduate Research Assistant March 2026 – Present

Physics Education Research — Dr. Zhongzhou Chen (NSF Award 2421299; Gates Foundation INV-076932)

- Research on automated assessment generation for introductory physics instruction: built ESTELA, a system producing multi-version isomorphic exams from structured problem banks, and a generation pipeline for new problems. Pilot runs showed generated answer keys contradicting their own questions, which the language-model reviewer missed; replaced its verdict with a deterministic check that derives the correct answer from the problem and rejects any draft that disagrees.
- Materials authored for the project are in use by external adopters following a faculty workshop. Manuscript in preparation.

FAU Grant-Funded AI Safety Research Project (High School) January 2024 – March 2025

Supervisor: Tucker Hindle, Florida Atlantic University

- Benchmarked 10+ coherence and detection methods (GPT-2 perplexity, RoBERTa, BERT NSP, LSA, NLI, burstiness) across 3,125+ generated sequences; identified GPT-2 perplexity as the strongest discriminator (3.3× separation between coherent and incoherent text).
- Characterized a consistent quality–evasion tradeoff across four adversarial humanization pipelines. Grant-funded with HPC access; presented at the Wilkes Honors College Symposium (2025).

OTHER EXPERIENCE

Secretary — National Society of Black Physicists (NSBP), UCF Chapter 2025 – Present

- Coordinate meetings, records, and communications for the UCF student chapter of the National Society of Black Physicists.

President — Coding Club, Florida Atlantic University (High School) 2023 – 2025

- Founded and led a student coding club; organized meetings and collaborative programming projects with peers.

Teaching Assistant — Calculus (High School) August 2024 – May 2025

- Assisted 70 undergraduate students with learning calculus; office hours, exam review, grading. Part-time (10 h/ week).

Advanced Experimental Vehicles — Programmer, Leader, Builder (High School) November 2023 – May 2025

- Configured Arch Linux ARM on Raspberry Pi 5 with Hyprland compositor and WireGuard VPN, enabling worldwide real-time telemetry monitoring of BMS, GPS, and camera feeds.
- Won 2nd Place in Division and Lockheed Martin Award for "Highest Level of Engineering Excellence."

PRESENTATIONS

Batch Processing for Automated Grading via Azure OpenAI June 2026

University of Central Florida, Downtown Campus. ESTELA project (Physics Education Research, Dr. Zhongzhou Chen).

Coherence and Detection Approaches for Identifying AI-Generated Text March 2025

Wilkes Honors College Undergraduate Research Symposium, Florida Atlantic University.

TECHNICAL REPORTS

Coherence and Detection Approaches for Identifying AI-Generated Text 2025

- Empirical study of AI-text detection and adversarial evasion: benchmarked 10 coherence and detection methods (GPT-2 perplexity best, 3.35× separation; RoBERTa the only effective detector) and built four evasion pipelines, characterizing a consistent quality–evasion tradeoff. Grant-funded, Florida Atlantic University.

SELECTED PROJECTS

Stardust — Bayesian Orbit Inference and Archival Recovery of Near-Earth Asteroids October 2026

- Propagates orbit uncertainty forward to find an asteroid where no one looked: starting from only the sightings that existed 4 days after discovery, a batched GPU N-body integrator in PyTorch (DE440 perturbers, solar relativity;

100,000 orbit samples × 1 year in 23 s) draws from the orbit-determination uncertainty and projects that distribution onto years of pre-discovery ZTF images, which a 1.9M-parameter U-Net (trained on 4,000 real cutouts) and a classic streak filter then search.
- Blind backtest on 72 asteroids once on NASA's Sentry impact-risk list: 167 verified, never-connected sightings of 22, tightening their orbits up to 52× (median 7.1×); frozen held-out rounds recovered 16 of 50. Live on 235 asteroids on today's Sentry list: 202 never-reported pre-discovery sightings of 23, each found independently by both detectors. The U-Net finds 57.5% of asteroids at the camera's limit, where the streak filter finds none. Validated against JPL on 2024 YR4 (2032 Earth miss 279,443 km vs. JPL's 278,333 km).

CELERIS — From-Scratch RCWA Solver & Metalens Inverse Design 2026

- Solver for Maxwell's equations in periodic subwavelength structures (rigorous coupled-wave analysis: Li/Liu–Fan factorization, 2D-vectorial $P \cdot Q$ formulation, Redheffer scattering-matrix recursion), validated layer by layer against closed-form physics, independent methods and energy conservation (S-matrix to 1e-14, Σ efficiency = 1.000000), cross-validated against the grcwa and Stanford S^4 solvers (TE to ≈ 1e-7), and reproducing canonical published metalenses (Khorasaninejad et al., *Science* 2016; Chen et al., *Nat. Nanotechnol.* 2018).
- Gradient-based (Adam) inverse design of metalenses, with fabrication-tolerance Monte-Carlo analysis and a CUDA far-field kernel ~ 120–190× faster than the multithreaded CPU path (laptop RTX 4070). C++23/CUDA with Python bindings. v1.0.0 archived on Zenodo (doi:10.5281/zenodo.21891345); sole-author JOSS submission planned for early 2027.

TECHNICAL SKILLS

Computational Physics: Monte Carlo uncertainty propagation, N-body integration, inverse problems & phase retrieval, scattering theory (Mie, Born/distorted-wave Born, coupled-dipole, Debye equation), electromagnetic simulation (RCWA), GPU/CUDA acceleration

Machine Learning & Data: PyTorch, convolutional networks (U-Net), NumPy, SciPy, FFT & signal processing

Instrumentation: interferometric alignment, tunable IR laser and motorized polarization control, GPIB/VISA, INDI, GigE Vision cameras, FITS & GDSII formats

Programming Languages: C/C++, CUDA, Python, Shell (Fish, Bash, tcsh), LaTeX/Typst

Tools: Linux (incl. embedded kernel bring-up on NVIDIA Jetson), Git, CMake, Ansible, Qt/PySide6

SELECTED COURSEWORK

Physics: Electricity & Magnetism I (in progress), Mathematical Methods for Physics, Modern Physics, Quantum Information Processing, Geometric Optics & Lab

Mathematics: Linear Algebra (proof-based, in progress), Partial Differential Equations (in progress), Complex Variables, Matrix & Linear Algebra, Statistical Methods

Computer Science: Deep Learning, Data Structures & Algorithm Analysis, Computer Architecture, Discrete Structures

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HONORS & AWARDS

UCF institutional nominee — Barry Goldwater Scholarship and Astronaut Scholarship 2026 – 2027

President's Honor Roll, University of Central Florida (Fall 2025, Spring 2026) 2025 – 2026

Florida Bright Futures — Florida Academic Scholars (highest tier; 100% tuition) 2025

Lockheed Martin Award — "Highest Level of Engineering Excellence," AEV Competition 2024

2nd Place in Division, Advanced Experimental Vehicles Competition 2024

1st Place, Night Hacks Hackathon — UniUtils (course schedule generator & classroom finder) 2023