AMARNATH S. PATEL

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EDUCATION

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

B.S. Physics (Optics & Lasers) and Mathematics, Computer Science minor August 2025 – Expected May 2029

- **Mathematics:** Applied Linear Algebra, Linear Algebra (proof-based, in progress), Complex Analysis, Partial Differential Equations (in progress), Mathematical Methods for Physics, Ordinary Differential Equations, Honors Calculus III, Discrete Structures
- **Physics:** Quantum Information Processing, Modern Physics, Geometric Optics & Lab, Electricity & Magnetism I (in progress), Independent Research

Florida Atlantic University University coursework via FAU High School, ages 14–18 (111 credit hours) **3.66 GPA**

- Deep Learning, Data Structures & Algorithms, Computer Architecture, Computer Logic Design

RESEARCH EXPERIENCE

CELERIS — Independent Research: From-Scratch RCWA Solver & Metalens Design Pipeline 2026

- Built a from-scratch solver for Maxwell's equations in periodic subwavelength structures via rigorous coupled-wave analysis: 1D TE/TM gratings with Li/Liu–Fan inverse-rule factorization, full 2D-vectorial formulation for biperiodic arrays, and stable Redheffer scattering-matrix recursion.
- Validated every layer of the stack against closed-form physics, an independent method, or energy conservation — RCWA vs. transfer-matrix to 1e-6, multilayer S-matrix to 1e-14, 2D⟶ 1D reduction (TE and TM) to $<$1e-10, summed diffraction efficiency 1.000000. Independently cross-validated against the grcwa and Stanford S^4 solvers (TE to $\approx$ 1e-7) and reproduces canonical published metalenses (Khorasaninejad et al., *Science* 2016; Chen et al., *Nat. Nanotechnol.* 2018).
- Gradient-based (Adam) inverse design over meta-atom parameter sweeps; Monte-Carlo fabrication-tolerance analysis; Strehl, Zernike wavefront, MTF and chromatic-focal-shift analysis battery.
- Accelerated Rayleigh–Sommerfeld far-field propagation as a CUDA kernel, ~120–190× faster than the project's own multithreaded CPU path (laptop RTX 4070), with single- and double-precision PSFs agreeing to $\leq$4.2e-5. C++23/CUDA with Python bindings. v1.0.0 archived on Zenodo; sole-author JOSS submission planned for early 2027.

Stardust — Archival Recovery of Near-Earth Asteroids October 2026

- Built the orbit and detection pipeline: a batched GPU N-body integrator in PyTorch samples a 4-day orbit's uncertainty (100,000 clones × 1 year in 23 s on a laptop GPU) and projects it onto years of archival ZTF images, searched by a U-Net detector and a classic streak filter. Blind backtest on 72 once-risky asteroids: 167 verified, never-connected sightings of 22, tightening orbits up to 52× (median 7.1×).

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

Supervisor: Dr. Stephen Eikenberry

- Measuring the wavelength-dependent complex transfer matrix of a photonic lantern by off-axis digital holography: align the interferometric bench and acquire holograms of the multimode output for each input port across the C-band (1525–1575 nm), recovering full amplitude and phase.
- Implemented the phase-retrieval and mode-decomposition analysis: FFT sideband isolation and demodulation, Butterworth low-pass, joint numerical optimization of mode-field diameter, defocus quadratic phase and field position, then decomposition onto the LP basis. Fidelity 97.2 ± 0.5% (51-frame single-port sweep) and 92.7 ± 1.7% (7-port sweep acquired by Rumana Akhter with this software); reproduced the lab's 19-port archive at 96.68 ± 1.58% over 969 frames (original run: 96.89%) in 65 s with 8 processes.
- Automated the four-instrument acquisition chain (HP 8168E tunable IR laser, Xenics Bobcat 320 InGaAs camera, DiCon GP700 fiber switch, Thorlabs MPC320 polarization control) over GPIB/VISA, RS-232 and GigE Vision, so a complete all-port × C-band sweep runs unattended with in-loop polarization optimization and saturated-frame rejection — reducing a full dataset from days of manual bench time to a single hands-off run.
- Own the node software for PolyOculus, a networked array of 8 telescopes: brought the array's Jetson Nanos up on mainline Linux (custom kernel, Ansible-managed fleet) to replace NVIDIA's end-of-life image, and wrote autoguiding to INDI mount guide pulses (simulated tracking error 3.01″ ⟶ 0.29″ RMS) and closed-loop piezo steering-mirror control (0.2 px).

Undergraduate Research Assistant — UCF Physics Department March 2026 – Present

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

- Built ESTELA, generating multi-version isomorphic exams from a structured bank of 615 problems across 29 banks, 13 topic areas and 11 question types, with auto-generated answer keys and export to four formats. Rust (Tauri 2). Materials in use by external adopters; manuscript in preparation.

Undergraduate Researcher — FAU Grant-Funded AI Safety Research Project January 2024 – March 2025

Supervisor: Tucker Hindle, Florida Atlantic University

- Benchmarked 10 statistical coherence and detection measures (GPT-2 perplexity, RoBERTa, BERT NSP, LSA, NLI, burstiness) on a 255,000-passage corpus; identified GPT-2 perplexity as the strongest discriminator (3.35× separation, 17.5 vs. 58.5) and showed BERT NSP to be uninformative.
- Built four adversarial evasion pipelines (iterative rewriting, tree-search decoding, list-branching, RL) over 3,125 generated sequences; characterized a consistent quality–evasion tradeoff. Grant-funded with HPC access; presented at the Wilkes Honors College Symposium.

TECHNICAL SKILLS

Numerical & Statistical Methods: FFT and signal processing, phase retrieval, modal decomposition, electromagnetic simulation (RCWA), gradient-based optimization, Monte-Carlo tolerance analysis, statistical discriminator benchmarking, GPU/CUDA acceleration

Programming: C/C++ (C++23), CUDA, Rust, Python (NumPy, SciPy), VHDL, Shell (Fish, Bash)

Tools: Linux, Git, CMake, Docker, Qt/PySide6, LaTeX/Typst; GPIB/VISA, RS-232, GigE Vision instrument control

HONORS & AWARDS

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

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