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Summary

AMO physicist with a Ph.D. from Columbia University specializing in molecular laser cooling and precision laser system design. Built complete laser systems from scratch including ECDLs, tapered amplifiers, injection locking amplifiers, Raman fiber amplifiers, full RF modulation chains, and custom UHV and 4K cryogenic apparatus. Published first-author work on direct laser cooling of CaH molecules. Co-founded a hardware robotics company, applying physics and engineering skills to build and ship four commercial automation products. U.S. Citizen.

Education

- 2017–2022 **Doctor of Philosophy, AMO Physics**, *Columbia University*, New York, NY.
Thesis: *Transverse Laser Cooling of Calcium Monohydride Molecules*
Advisor: Prof. Tanya Zelevinsky, Zelevinsky Lab
- 2013–2017 **Bachelor of Arts and Science, Magna Cum Laude**, *University of Colorado*, Boulder, CO.
Major: Physics

Research Experience

- 2018–2022 **Lead Graduate Researcher**, *Zelevinsky Lab, Columbia University Physics Dept.*, New York, NY.
Led the molecular laser-cooling experiment from junior student on BaH cooling to senior student directing the CaH cooling experiment. Built the complete laser system from scratch: ECDL lasers (Littrow & Littman-Metcalf), tapered amplifiers, injection locking amplifiers, Raman fiber amplifiers, and full RF modulation chain (EOMs, AOMs, RF amplifiers, VCOs, DDS). Implemented Doppler-free saturation spectroscopy and Fizeau interferometer locking for laser frequency stabilization. Wrote LabVIEW, Python, and C++ experiment control software. Designed and fabricated custom UHV vacuum components and a 4K cryogenic helium pulse tube refrigerator; modeled cryostat thermal performance in COMSOL. Operated single-photon EMCCD cameras, silicon photomultipliers, and analogue PMTs for quantum state detection.
- Summer 2017 **Graduate Researcher**, *Will Group, Columbia University*, New York, NY.
Built PID lock boxes for laser frequency stabilization, constructed a Doppler-free absorption spectroscopy reference for cesium, and calculated confinement potentials for a 2D MOT to improve atomic loading efficiency.
- 2015–2017 **Undergraduate Researcher**, *Nagle Group, University of Colorado Boulder*, Boulder, CO.
Designed and built an automated QC test stand for gain uniformity measurements of sPHENIX hadronic calorimeter scintillator panels. Developed a C++ pile-up detection algorithm incorporated into the PHENIX collaboration software library and used in 20+ published analyses.

April 2016 **Visiting Researcher**, *Fermi National Accelerator Laboratory*, Batavia, IL.
Assembled and tested prototype hadronic calorimeter components for sPHENIX; operated the collider DAQ system.

Professional Experience

Jan 2022–Present **Co-Founder & CTO**, *Rooted Robotics (formerly Urban Farms Inc.)*, Boulder/Denver, CO.
Raised \$1.2M through USDA SBIR grants and private investors. Applied physics and precision hardware skills to design, build, and ship four commercial automation products from concept to market, growing revenue from \$0 to \$700K/year. Products achieved CE certification (EU market clearance); 3 patents pending. Designed all mechanical and electrical systems, wrote all firmware (Python, C++), and deployed production computer vision pipelines (RealSense, YOLO V5, AWS Rekognition). Led engineering team of 5.

Technical Skills

Laser Sources: ECDLs (Littrow & Littman-Metcalf), Tapered Amplifiers, Injection Locking Amplifiers, Raman Fiber Amplifiers.

Laser Stabilization: Doppler-Free Saturation Spectroscopy, Fizeau Interferometer Locking, PDH Locking.

Electro-Optics: AOMs, AODs, EOMs, Scanning Fabry-Perot Cavities.

Detection & Imaging: EMCCD Single-Photon Cameras, Silicon Photomultipliers, Analogue PMTs, Imaging System Design, In-Vacuum Optics Design & Fabrication.

RF Electronics: Spectrum Analysers, DDS RF Signal Generators, RF Amplifiers, VCOs, PID Lock Boxes.

Vacuum: Custom UHV Chamber Design, MOT Chamber Design, In-Vacuum Optics Fabrication.

Cryogenics: Custom 4K Cryogenic Cell, Charcoal Absorber Design & Fabrication, Pulse Tube Refrigerator Maintenance.

Software: Python, C++, SQL, MATLAB, $\text{\LaTeX}$, LabVIEW, Custom Experiment Control Software.

Simulation: COMSOL, LightTools, Mathematica.

ML / CV: PyTorch, YOLO V5, AWS Rekognition.

Publications

First-author S. Vázquez-Carson et al., *Direct laser cooling of calcium monohydride molecules*, New Journal of Physics, 2022. arXiv:2203.04841

Co-author R. McNally, I. Kozyrev, S. Vázquez-Carson et al., *Optical cycling, radiative deflection and laser cooling of barium monohydride (BaH)*, New Journal of Physics, Vol. 22, 2020. arXiv:2004.09570

Co-author C. Aidala et al., *Creating Small Circular, Elliptical, and Triangular Droplets of Quark-Gluon Plasma*, Nature Physics, 2019, Vol. 15.

Full publication list (22 papers, 1315 citations): [Google Scholar](#)

Languages

English Native (U.S. Citizen)

Spanish Native