

RACHEL E. MORGAN

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US Citizen

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RESEARCH INTERESTS

Integrated photonics for space applications, remote sensing, astronomical instrumentation, adaptive optics, optical communications, satellite engineering

EDUCATION

MASSACHUSETTS INSTITUTE OF TECHNOLOGY 5.0/5.0 GPA
PhD in Aerospace Engineering Summer 2023
Thesis: Germanium-on-Silicon Integrated Photonics Platform for the Mid-Wave Infrared NASA Space Technology and Research Fellow

MASSACHUSETTS INSTITUTE OF TECHNOLOGY 5.0/5.0 GPA
Master of Science in Aerospace Engineering 2020
SM Thesis: Optical Modeling and Validation for the Deformable Mirror Demonstration Mission

MASSACHUSETTS INSTITUTE OF TECHNOLOGY 4.9/5.0 GPA
Bachelor of Science in Aerospace Engineering and Physics 2018

RESEARCH AND WORK EXPERIENCE

MIT LINCOLN LABORATORY: INTEGRATED NANOSYSTEMS AND QUANTUM INFORMATION GROUP

Graduate Researcher Cambridge, MA
Mid-wave Infrared Integrated Photonics 2020-Present

- Developing Germanium-on-Silicon integrated photonics platform for the mid-wave infrared wavelength range (2-5 μm) for chemical sensing and other applications
- Design and lab demonstration of low-loss waveguides (<2 dB/cm), passive component library (couplers, ring resonators, tapers, Mach-Zehnder Interferometers), and active component library (plasma dispersion effect modulators, thermal phase shifters)
- Trained intern in electromagnetic simulation software and laboratory testing

Integrated Photonics for Trapped-Ion Applications 2020-Present

- Design of grating couplers (Lumerical) in silicon-nitride platform to focus visible and infrared light from a photonic integrated chip to a set location in free space for a trapped-ion atomic clock experiment

- Applying inverse design methodology (Lumerical/Python) to grating coupler and expanding taper design
- Characterization of nitride and alumina waveguide-integrated silicon photodetectors for blue, red, and infrared wavelengths

MIT SPACE TELECOMMUNICATIONS, ASTRONOMY, AND RADIATION LABORATORY

Graduate Researcher

Cambridge, MA

Optical Engineer for DeMi CubeSat

2018-Present

- Integration, alignment, calibration, and testing of the Deformable Mirror Demonstration Mission (DeMi) CubeSat optical payload
- Developed optical propagation model of optical payload (Python) and validated with system engineering model and flight unit
- Developed payload camera driver software (C/C++) and supervised undergraduate researcher in testing and characterizing flight cameras
- Lead team of 8 graduate students in flight payload integration into spacecraft and spacecraft environmental testing (thermal, thermal vacuum, and vibration testing)
- Developed commanding and operations software (Ruby/COSMOS) for environmental testing and flight operations
- Commanded >300 satellite overpasses and analyzed payload data from space operations demonstrating wavefront control in space with a MEMS DM for first time

MIT SPACE TELECOMMUNICATIONS, ASTRONOMY, AND RADIATION LABORATORY

Undergraduate Researcher

Cambridge, MA

Exoplanet Image Processing

2017-2018

- Analyzed data collected from the Magellan Clay Telescope to image a debris disk around the Epsilon Eridani system, applied Karhunen-Loeve Image Processing (KLIP) algorithm to subtract residual starlight from coronagraph images
- Adapted software tools for post processing (Python) for data from a new instrument

CubeSat Laser Communications

2015 - 2017

- Designed, prototyped, and tested optical transceiver for the CubeSat Lasercom Infrared Crosslink (CLICK) project which will demonstrate an optical communications cross link between two CubeSats
- Calculated optical link budgets to analyze system design (MATLAB)
- Built optical test setups to test fine pointing algorithms with Fast Steering Mirrors
- Supported design and analysis of optical ground station for the Nanosatellite Optical Downlink Experiment (NODE) by retrofitting and testing a commercial telescope to track CubeSats and receive laser signals

NASA JET PROPULSION LABORATORY

Intern

Pasadena, CA

Systems Engineering and Optical Communications

Summer 2018

- Created integration and test plan for Deep Space Optical Communications technology demonstration payload
- Developed code (MATLAB) to simulate pointing jitter of spacecraft and used simulation to test interleaver properties on single photon detecting receiver cryogenic camera testbed
- Developed code (Python) to query star catalog to select best pointing calibration targets for ground system pointing calibration
- Analyzed data from on-sky ground station pointing tests

Systems Engineering

Summer 2017

- Performed early-stage systems engineering tasks for the Psyche spacecraft mission. Led meetings for key spacecraft and optical communications experts in order to create payload and ground systems operations plan
- Wrote preliminary concept of operations and requirements for the Deep Space Optical Communications technology demonstration payload
- Created content for detailed infographics to communicate the mission design and integration process to the public

Optical Communications

Summer 2016

- Analyzed effect of Earth's atmospheric channel on laser communication signals using lidar data from Table Mountain Facility optical ground station in preparation for the Laser Communications Relay Demonstration mission
- Calculated optical attenuation and cloud cover statistics in order to characterize atmospheric effects at the ground station location and validate cloud detection algorithms used by thermal infrared cloud camera instrument

AWARDS AND HONORS

- **Carl E. Nielsen, Jr. Award** for Excellence in Graduate Student Research at MIT Lincoln Laboratory, 2021
- **1st Place in the Frank J Redd Student Paper Competition** at the AIAA/USU 2020 Conference on Small Satellites for paper and oral presentation "Optical Modeling, Alignment, and Testing for the Deformable Mirror Demonstration Mission (DeMi) CubeSat Payload"
- Selected for **Amelia Earhart Fellowship Award**, Spring 2020
- MIT AeroAstro **Apollo Award** for leadership and excellent contributions to the DeMi space mission, Spring 2020
- Selected for **NSF Graduate Research Fellowship Program**, Spring 2018
- Selected for **NASA Space Technology Research Fellowship Program**, Spring 2018
- MIT AeroAstro **James Means Award for Excellence in Space Systems Engineering** for work in senior capstone engineering project, 2018.

- **Nordloff Award for Distinguished Service** to MIT Wind Ensemble, 2018.
- Elected to MIT Chapter of **Phi Beta Kappa** National Honor Society, Spring 2018
- MIT SuperUROP **Outstanding Research Project Award** for project entitled “Nanosatellite Lasercom System”
- **2nd Place** in the Frank J Redd Student Paper Competition at the AIAA/USU 2017 Conference on Small Satellites for paper and oral presentation “Nanosatellite Lasercom System”
- Student member of **SPIE**, 2017-present
- Member of **American Astronomical Society**, 2017-Present

SKILLS AND ACTIVITIES

- **Computer skills:** Python, Lumerical Electromagnetics Simulation Suite, MATLAB, C/C++
- **Hardware skills:** Passive and active integrated photonics component testing, optical setups and alignment, fiber cleaving and splicing, clean room/ESD trained, satellite environmental testing
- **Language skills:** Italian
- **MIT Wind Ensemble:** Alto/Tenor/Baritone/Bass Saxophone, Social Chair, Fall 2014 – Present
- **MIT Aero Astro Departmental Resources for Easing Friction and Stress:** promote mental health and wellness for graduate students in the department through events and one-on-one meetings with students, trained in conflict management, 2020-Present
- **MIT Graduate Women in Aerospace Engineering: Outreach Committee Chair:** Organize and volunteer at outreach events at MIT and in the local Boston community, 2019 - Present
- **2019 American Astronomical Society Astro-Ambassador:** Completed astronomy outreach workshop to develop skills in STEM outreach, January 2019.
- **MIT Global Teaching Labs Scotland:** Taught courses on fun topics in physics to middle/high school students at Robert Gordon’s College in Aberdeen, Scotland, January 2018.
- **MIT Women in Aerospace Engineering, President:** Lead local outreach, professional development, and mentorship programs for women interested in aerospace, Spring 2016 – 2018.
- **UCSC Summer School on Adaptive Optics, Lab Instructor:** Taught lab sessions for summer school students to build their own Shack Hartmann wavefront sensors, Summer 2018.

JOURNAL PUBLICATIONS

Morgan R., Douglas E., Allan G., et al., “Optical calibration and first light for the deformable mirror demonstration mission CubeSat (DeMi).” *Journal of Astronomical Telescopes and Instrument Systems* 7 (2) 2021. doi: 10.1117/1.JATIS.7.2.024002.

Douglas E., Allan G., **Morgan R.**, et al., “Small Mirrors for Small Satellites: Design of the Deformable Mirror Demonstration Mission (DeMi) CubeSat Payload.” *Frontiers in Astronomy and Space Sciences*, Section on Astronomical Instrumentation. 26 August 2021. doi:10.3389/fspas.2021.676281.

Morgan R., Douglas E., Allan G., et al., “MEMS Deformable Mirrors for Space-Based High Contrast Imaging.” *Micromachines* 10 (6), 366, 2019. doi:10.3390/mi10060366.

Carlton A, Lohmeyer W, **Morgan R**, Cahoy K. "Fault detection algorithms applied to spacecraft telemetry for monitoring and environmental sensing." Journal of Aerospace Information Systems Vol 15(5) 2018. doi:10.2514/1.I010587.

Clements E, Cahoy K, ... **Morgan R**, et al; "Nanosatellite optical downlink experiment: design, simulation, and prototyping." Optical Engineering 0001;55(11):111610 2016. doi:10.1117/1.OE.55.11.111610.

CONFERENCE PUBLICATIONS

Morgan R., Heidelberger C., Kharas D., et al. "Low-loss Germanium-on-Silicon Waveguides and Ring Resonators for the Mid-Wave Infrared." Conference on Lasers and Electro Optics SW50.1 2022.

Morgan R., Vlahakis S., Douglas E., et al. "On-Orbit Operations Summary for the Deformable Mirror Demonstration Mission (DeMi) CubeSat." Proceedings of SPIE Astronomical Telescopes and Instrumentation 12185 2022.

Morgan R., Kharas D., Sorace-Agaskar C., et al. "Waveguide-Integrated Blue Light Detector." IEE Photonics Conference WG2.2 2021.

Morgan R. Vlahakis S., Allan G., et al. "Operations Update for the Deformable Mirror Demonstration Mission (DeMi) CubeSat. Advanced Maui Optical and Space Surveillance Technologies Conference 2021.

Sorace-Agaskar C., Aull B., Braje D., ... **Morgan R.** et al., "Integrated Photonic Circuits and Platform Development for Trapped-Ion Quantum Computing and Sensing." OSA Advanced Photonics Congress ITh2A.2 2021.

Morgan R. "Optical Modeling, Alignment, and Testing for the Deformable Mirror Demonstration Mission (DeMi) CubeSat Payload." Proceedings of the AIAA/USU Conference on Small Satellites 2020. *Awarded 1st Place in Frank J Redd Student Paper Competition.*

do Vale Pereira P., Holden B., **Morgan R.**, et al. "Thermomechanical design and testing of the Deformable Mirror Demonstration Mission (DeMi) CubeSat". Proceedings of the AIAA/USU Conference on Small Satellites 2020.

Morgan R., Allan G., Douglas, E., "Optical Modeling and Testing of the Deformable Mirror Demonstration Mission (DeMi) CubeSat Payload," SPIE Proceedings Optics and Photonics 2019.

Holden B., **Morgan R.**, Allan G., et al., "Calibration and Testing of the Deformable Mirror Demonstration Mission (DeMi) CubeSat Payload," Proceedings of the AIAA/USU Conference on Small Satellites 2019.

Morgan R., Douglas, E., Cahoy, K., et al., "Surveying the Epsilon Eridani System Using MagAO," Proceedings of SPIE: Astronomical Telescopes and Instrumentation 2018.

Morgan R; "Nanosatellite Lasercom System." Proceedings of the 31st Annual AIAA/USU Conference on Small Satellites 2017. *Awarded 2nd Place in Frank J Redd Student Paper Competition.*

CONFERENCE PRESENTATIONS

Morgan R., Heidelberger C., Sorace-Agaskar, C. et al. "Low-loss Germanium-on-Silicon Waveguides and Ring Resonators for the Mid-Wave Infrared." Conference on Lasers and Electro Optics SW50.1. Oral Presentation, May 2022.

Morgan R., Kharas D., Sorace-Agaskar C., et al. "Waveguide-Integrated Blue Light Detector." IEE Photonics Conference WG2.2. Oral Presentation, November 2021.

Morgan R. Vlahakis S., Allan G., et al. "Operations Update for the Deformable Mirror Demonstration Mission (DeMi) CubeSat. Advanced Maui Optical and Space Surveillance Technologies Conference. Oral Presentation, September 2021.

Morgan R. "Optical Modeling, Alignment, and Testing for the Deformable Mirror Demonstration Mission (DeMi) CubeSat Payload." Proceedings of the AIAA/USU Conference on Small Satellites 2020. Oral Presentation, August 2020. *Awarded 1st Place in Frank J Redd Student Paper Competition.*

Morgan R., Allan G., Douglas, E., "Flight Integration and Testing for the Deformable Mirror Demonstration Mission (DeMi) CubeSat," 2020 American Astronomical Society Meeting. Oral presentation, January 2020.

Morgan R., Allan G., Douglas, E., "Assembly, Integration, and Testing of the Deformable Mirror Demonstration Mission (DeMi) CubeSat Payload," In the Spirit of Lyot Conference 2019. Poster presentation, October 2019.

Morgan R., Allan G., Douglas, E., "Optical Modeling and Testing of the Deformable Mirror Demonstration Mission (DeMi) CubeSat Payload," SPIE Optics and Photonics 2019. Oral Presentation, August 2019.

Morgan R., Allan G., Douglas, E., "Integration and Testing of the Deformable Mirror (DeMi) CubeSat Payload." 2019 CalPoly CubeSat Developer's Workshop. Oral Presentation, April 2019.

Morgan R., Allan G., Douglas, E., "Integration and Testing of the Deformable Mirror CubeSat Payload." 2019 American Astronomical Society Meeting. Oral Presentation, January 2019.

Morgan R, Douglas, E., Cahoy, K., et al., "Surveying the Epsilon Eridani System Using MagAO," Proceedings of SPIE: Astronomical Telescopes and Instrumentation 2018. Poster Presentation, June 2018.

Morgan R; "Nanosatellite Lasercom System." Proceedings of the 31st Annual AIAA/USU Conference on Small Satellites. Oral Presentation, August 2017. *Awarded 2nd Place in Frank J Redd Student Paper Competition.*

INVITED TALKS

NASA JPL Photonics Seminar Series: "MWIR Integrated Photonics with a Germanium-on-Silicon Platform." October 2021.

NASA Goddard Space Flight Center Presentation: "Mid-wave Infrared Integrated Photonics with a Germanium-on-Silicon Platform." October 2021.

Laboratoire d'Astrophysique de Marseille (LAM) Optics Research and Development (GRD) Seminar: "Operations Update for the Deformable Mirror (DeMi) CubeSat." July 2021.

NASA JPL Seminar: "Calibration, Environmental Testing, and Operations Update for the Deformable Mirror (DeMi) CubeSat." August 2020.

Harvard Exoplanet Pizza Lunch Seminar: "Calibration, Environmental Testing, and Operations Update for the Deformable Mirror (DeMi) CubeSat." November 2019.