

# ISMAEL MENDOZA

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## EDUCATION

### University of Michigan

PhD Physics and Scientific Computing Candidate, **GPA: 3.96**

*Ann Arbor, MI*

*September 2019 – Present*

### Stanford University

MS Computer Science, **GPA: 3.74**

*Stanford, CA*

*September 2018 - June 2019*

- **Research in Statistics and Cosmology:** “Effects of Overlapping Sources on Cosmic Shear Estimation: Statistical Sensitivity and Pixel-Noise Bias”

BS Physics with Honors & Minor in Statistics, **GPA: 3.86**

*September 2014 - June 2018*

- **Honors Thesis:** “No escape: light waves in AdS” ([Link](#))

## RESEARCH EXPERIENCE

### Weak Lensing Bayesian Pipeline

*Argonne National Laboratory, IL*

Matthew Becker (Weak Lensing)

*March 2022 – Present*

- Lead topical team inside LSST DESC with goal of creating a fully Bayesian analysis pipeline for LSST.
- Developed [JAX-GalSim](#), a fully differentiable drop-in replacement to the galaxy simulation package, GalSim, that enables GPU acceleration and inference via Hamiltonian Monte Carlo (HMC).
- Developing proof-of-concept cosmic shear inference pipeline for LSST-like astronomical images.

### Galaxy-Halo Connection in N-body Cosmological Simulations

*University of Michigan, MI*

Advisor: Camille Avestruz (Cosmology)

*September 2019 – Present*

- Used dark matter halo catalogs from N-body simulations to connect the dynamical history and present-day properties of haloes.
- Created pipeline to extract dark matter halo present-day properties, merger tree information, and subhalo information for a random subset of haloes at fixed mass.
- Designed and implemented statistical model to predict present-day dark matter halo properties from its accretion histories.
- Developing extension to predict clustering of galaxies in hydrodynamical simulation based on dark matter-only properties.

### Probabilistic Modeling with Machine Learning in Cosmological Surveys *University of Michigan, MI*

Advisor: Jeffrey Regier (Statistics)

*October 2019 – June 2024*

- Maintained and developed [BLISS](#), an open-source Python package designed to measure visually overlapping (blended) galaxies in state-of-the-art astronomical surveys.
- Built probabilistic model to measure blended galaxy images using techniques from variational inference and deep generative modeling.
- Created pipeline to train, validate, and test machine learning algorithms on real astronomical images.

### Leadership in Open Source Software Development

*University of Michigan, MI*

Advisor: Camille Avestruz (Physics)

*June 2020 – June 2024*

- Lead maintainer and developer of the [BlendingToolKit](#), a software tool kit for evaluating performance metrics for detection, deblending and measurement algorithms, applied to images of blended galaxies.
- Presented software tutorials at collaboration meetings, which recruited a team of contributors.

- Led team to extend user interface, incorporate realistic galaxy simulations, and create additional tutorials and documentation.

**Impact of Blending on Weak Lensing Measurements with Fisher Formalism** *Stanford, CA*  
 Advisor: Patricia Burchat (Cosmology) *June 2015 – April 2021*

- Developed software package to measure the impact of galaxy-galaxy blending on shape measurement noise bias.
- Applied the Fisher formalism to assess the impact of blending on cosmic shear estimation for several astronomical surveys.
- Publication accepted to the Journal of Cosmology and Astrophysics (JCAP).

**Biostatistics** *Stanford, CA*  
 Advisor: Julia Palacios (Statistics and Biomedical Data Science) *September 2018 – June 2019*

- Implemented efficient algorithms for calculating the likelihood of phylogenetic trees simulated from coalescent models.
- Developed Bayesian statistical framework to calculate the probability of correct classification between two different population size histories for large sample sizes and loci.

**Convex Optimization** *Lausanne, Switzerland*  
 Advisor: Nisheeth Vishnoi (Theoretical Computer Science) *June 2018 – September 2018*

- Participated in Summer@EPFL CS program at the École polytechnique fédérale de Lausanne (EPFL).
- Designed and executed a project at interface of optimization, cosmology, and Riemannian geometry.
- Developed manifold optimization algorithms to measure galaxy shapes from surface brightness profiles.
- Used non-convex optimization techniques to mathematically show the high efficiency of my algorithm.

**General Relativity and Field Theory Honors Thesis** *Stanford, CA*  
 Advisor: Eva Silverstein (Cosmology) *June 2017 – June 2018*

- Developed a framework for understanding scattering processes in manifolds by combining insights from quantum scattering theory, differential geometry, and partial differential equations.
- Applied framework to successfully resolve paradox of light waves traveling in Anti-de Sitter space.
- Simulated complex wave scattering processes using Mathematica.
- Presented work as my undergraduate Honors Thesis to the Stanford Physics Undergraduate Committee and at the Stanford Symposium of Undergraduate Research (SURPS).

## TEACHING EXPERIENCE

**Course development at the University of Michigan** *Ann Arbor, MI*

- **Courses:**
  - Physics 104: Introduction to Python Programming *July 2022*
- Developed course materials for this new course, as well as a midterm/final project.

**Instructor, Summer Program in Quantitative Methods for Social Research** *Ann Arbor, MI*

- **Courses:**
  - Introduction to Python *July 2022*
- Designed and executed a 10-day bootcamp to introduce Python to newcomers.
- Emphasized a hands-on approach using Jupyter notebooks and encouraged interaction during lectures.

**Statistics Teaching Assistant at the University of Michigan** *Ann Arbor, MI*

- **Courses:**
  - Statistics 507: Data Science and Analytics using Python *August 2020 – December 2020*
- Led discussions sections to help students understand Python's scientific computing stack, relational databases (SQL), and deep learning using `pytorch`.

- Designed and graded weekly programming assignments.
- Planned and executed a **kaggle** competition as their final project.

#### **Physics Teaching Assistant at the University of Michigan**

*Ann Arbor, MI*

- **Courses:**
  - Physics 136: Physics for the Life Sciences Laboratory I *September 2019 – December 2019*
  - Physics 141: Elementary Laboratory I *January 2020 – April 2020*
  - Physics 453: Quantum Mechanics *January 2022 – April 2022*
  - Physics 505: Classical fields and Electromagnetism I *September 2023 – December 2023*
- Guided students through a series of physics experiments including analysis of their measurements.
- Facilitated group discussions and provided regular feedback on student's performance.

#### **Physics Teaching Assistant at Stanford University**

*Stanford, CA*

- **Courses:**
  - Physics 21: Mechanics, Fluids, and Heat *September 2018 – December 2018*
  - Physics 70: Foundations of Modern Physics *September 2017 – December 2017*
- Designed and graded weekly problem sets, quizzes, and exams.
- Lead weekly problem-solving sessions aimed at reinforcing student's understanding of lecture.

**EPASA:** Tutored middle school student in Math and English.

*September 2016 – June 2018*

**Habla:** Tutored Stanford custodial staff in English 3 hours/week.

*September 2014 – June 2018*

### **LEADERSHIP ROLES**

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**Sprint Coordinator for LSST DESC:** Organize hackathons and tutorials for the Dark Energy Science Collaboration.

**Topical Team Lead for LSST DESC:** Organize scientific teams to develop software that accomplishes scientific goals within the collaboration.

**Physics Graduate Council at the University of Michigan:** Represent the graduate student body at a department level, and organize social events to help build community.

**Life in Graduate School Seminar Council at the University of Michigan:** Organize bi-weekly seminars for Physics graduate students to learn about resources at the university that can help them during their PhD.

### **SKILLS**

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- *Python:* 8+ years of experience in using Python for coursework and several research projects, including comprehensive knowledge of its scientific computing stack: **numpy**, **scipy**, **scikit-learn**, **matplotlib**.
- *Machine Learning:* Extensive experience designing and testing neural networks in **pytorch**, developing ML pipelines for complex science applications, and knowledge of cutting-edge algorithms such as variational autoencoders and normalizing flows.
- *Other Programming Languages:* C/C++, **L<sup>A</sup>T<sub>E</sub>X**, Mathematica, Unix shell, Git
- *Languages:* Native Spanish speaker

### **HONORS AND AWARDS**

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**Science Graduate Student Research (SCGSR) award** – U.S. DOE Office *2024*

**Department Fellowship, Knoller Fund** – UofM Physics Department *2024*

**Leinweber Center for Theoretical Physics Summer Fellowship** – UofM Physics Department *2023*

**Walter F. Lewis Candidacy Fellowship** – University of Michigan Physics Department *2022*

**Science Communication Fellowship** – University of Michigan Museum of Natural History *2022*

## Computational and Data Science Fellowship –

ACM’s Special Interest Group on High Performance Computing (SIGHPC) 2021

**Graduate Fellowship** – Michigan Institute for Computational Discovery & Engineering 2021

**Enabling Science Award** – Large Synoptic Survey Telescope Corporation 2016 & 2021

**Research Grant** – Stanford Undergraduate Advising and Research 2017

**Bronze Medalist** – 45th International Physics Olympiad 2014

## PUBLICATIONS

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Mendoza, I., Mansfield, P., Wang, K., and Avestruz, C. (2023). MultiCAM: a multivariable framework for connecting the mass accretion history of haloes with their properties. *Monthly Notices of the Royal Astronomical Society*, 523(4), 6386-6400.

**Mendoza, I.**, Liu, R., Hansen, D., Zhao, Z., Pang, Z., Avestruz, C., Regier, J., for the LSST Dark Energy Collaboration, “Simulation-Based Inference for Probabilistic Light Source Detection, Deblending, and Measurement”, submitted to the Dark Energy Science Collaboration (DESC) for internal review.

**Mendoza, I.**,<sup>\*</sup> Torchylo, A.,<sup>\*</sup> Sainrat, T., Guinot, A., Boucaud, A., Paillasa, M., Avestruz, C., Prakruth, A., Aubourg, E., Biswajit, B., Buchanan, J., Burchat P., Doux, C., Joseph, R., Kamath, S., Malz, A. I., Merz, G., Miyatake, H., Roucelle, C., for the LSST Dark Energy Science Collaboration, “The Blending ToolKit: A simulation framework for evaluation of galaxy detection and deblending”, submitted to the Dark Energy Science Collaboration (DESC) for internal review.

Wang, M.,<sup>\*</sup> **Mendoza, I.**,<sup>\*</sup> Wang, C., Avestruz, C., and Regier, J., “Statistical Inference for Coadded Astronomical Images”. arXiv preprint arXiv:2211.09300. Accepted to the *Machine Learning and the Physical Sciences Workshop at the 36th conference on Neural Information Processing Systems (NeurIPS)*.

Hansen, D.,<sup>\*</sup> **Mendoza, I.**,<sup>\*</sup> Liu, R., Pang, Z., Zhao, Z., Avestruz, C., and Regier, J., “Scalable Bayesian Inference for Detection and Deblending in Astronomical Images”, arXiv preprint arXiv:2207.05642. Accepted to the *ICML 2022 Workshop on Machine Learning for Astrophysics*.

Sanchez, J., **Mendoza, I.**, Kirkby, D. P., Burchat, P. R., for the LSST Dark Energy Science Collaboration, “Effects of overlapping sources on cosmic shear estimation: Statistical sensitivity and pixel-noise bias”, *Journal of Cosmology and Astroparticle Physics*, 2021(07), 043.

## PRESENTATIONS

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*Mitigating the Blending Problem in Cosmology*, Ismael Mendoza, Invited talk at Astrocoffee, Department of Physics and Astronomy at the University of Pittsburgh, Pittsburgh, PA, October 2023

*The Blending Problem in Cosmology*, Ismael Mendoza, Invited talk at the KIPAC Tea, Kavli Institute for Particle Astrophysics and Cosmology at Stanford University, Stanford, CA, July 2023

*Bayesian Light Source Separator (BLISS): Probabilistic detection, deblending and measurement of astronomical light sources*, Ismael Mendoza, Invited talk at Statistical Challenges in Modern Astronomy VIII, Pennsylvania State University, State College, PA, June 2023

*MultiCAM: A multivariable framework for connecting the mass accretion history of haloes with their properties*, Ismael Mendoza, Invited talk at the Baryon Pasting Collaboration Meeting, Yale University, New Haven, CT, May 2023

*MultiCAM: A multivariable framework for connecting the mass accretion history of haloes with their properties*, Ismael Mendoza, The Co-evolution of the Cosmic Web and Galaxies across Cosmic Time Conference Poster Session, Kavli Institute for Theoretical Physics (KITP), Santa Barbara, CA, February 2023

*Statistical Inference for Coadded Astronomical Images*, Mallory Wang and Ismael Mendoza, Machine Learning and the Physical Sciences Workshop at the 36th conference on Neural Information Processing Systems (NeurIPS 2022) Poster Session, New Orleans, LA, December 2022

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<sup>\*</sup> Equal contribution

*Bayesian Light Source Separator (BLISS)*, Ismael Mendoza, Dark Energy Science Collaboration (DESC) Summer Meeting Poster Session, Chicago, IL., August 2022

*Scalable Bayesian Inference for Detection and Deblending in Astronomical Images*, Ismael Mendoza, ICML 2022 Workshop on Machine Learning for Astrophysics Poster Session, Baltimore, MA, July 2022

*Machine Learning in Cosmology*, Ismael Mendoza, Physics Graduate Student Symposium 2022, Ann Arbor, MI, June 2022

*Updates on the Bayesian Light Source Separator (BLISS)*, Ismael Mendoza, Dark Energy Science Collaboration (DESC) Bayesian Pipelines Topical Team Telecon, April 2022 (virtual)

*Connecting the Properties of Dark Matter Haloes with Their Growth*, Ismael Mendoza, University of Michigan Clusters Group, Ann Arbor, MI, March 2021 (virtual)

*Effects of overlapping sources on cosmic shear estimation: Statistical sensitivity and pixel-noise bias*, Javier Sanchez & Ismael Mendoza, Collaboration-Wide Presentation for the Dark Energy Science Collaboration (DESC). February 2021 (virtual)

*BlendingToolKit Tutorial*, Ismael Mendoza, Dark Energy Science Collaboration (DESC) Summer 2020 Virtual Meeting, Chicago, IL, July 2020 (virtual)

*The Blending Problem in Cosmology*, Ismael Mendoza, Physics Graduate Student Symposium 2020, Ann Arbor, MI, July 2020 (virtual)

*BlendingToolKit: Walkthrough and Future Plans*, Ismael Mendoza, DESC Blending Working Group. July 2020 (virtual)

## BLOGS

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*MathStatBites at SCMA8: Astro Image Processing is BLISS?*, Andrew Saydjari for MathStatBites, <https://mathstatbites.org/mathstatbites-at-scma8-astro-image-processing-is-bliss/>

*The Crowded Cosmos: Effects of Blended Galaxies on Cosmic Shear*, Katya Gozman for AstroBites, <https://astrobites.org/2021/03/20/blended-galaxies-cosmic-shear/>