ISMAEL MENDOZA

(+1) 734 834 2794 imendoza@umich.edu
https://ismael-mendoza.github.io https://github.com/ismael-mendoza

EDUCATION

University of Michigan *Ann Arbor, MI*
PhD Physics Candidate, **GPA: 3.96** *September 2019 – Present*

Stanford University *Stanford, CA*
MS Computer Science, **GPA: 3.74** *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

Bayesian Shear Inference via Forward Modeling *Argonne National Laboratory, IL*
Matthew Becker (Weak Lensing) *August 2024 – Present*

- Developed JAX-GalSim, a fully differentiable replacement to the popular galaxy image simulation package, GalSim.
- We leverage JAX-Galsim to develop a new Bayesian cosmic shear measurement algorithm, which uses GPUs and gradient-based MCMCs for inference.

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 ML in Cosmology 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

Topical Team Lead for LSST DESC (2020 - Present): Manage scientific teams to develop software that accomplishes scientific goals within the collaboration.

Sprint Coordinator for LSST DESC (2022-2023): Organize hackathons and tutorials for the Dark Energy Science Collaboration.

Physics Graduate Council at the University of Michigan (2022-2024): Represent the graduate student body at a department level, and organize social events to build community.

Life in Graduate School Seminar Council at the University of Michigan (2023): Organize bi-weekly seminars for Physics graduate students to learn about resources at the university that can help them during their PhD.

SKILLS

• *Python:* 9+ 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++, LaTeX, Mathematica, Unix shell, Git

• *Languages*: Native Spanish speaker

HONORS AND AWARDS

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

Mendoza, I.,* Torchylo, A.,* Sainrat, T., Guinot, A., Boucaud, A., Paillasa, M., Avestruz, C., Adari, P., Aubourg, E., Biswas, B., Buchanan, J., et al. (2024). "The Blending ToolKit: A simulation framework for evaluation of galaxy detection and deblending". arXiv preprint arXiv:2409.06986. Submitted to the Open Journal of Astrophysics.

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.

Wang, M.,* **Mendoza, I.**,*, Wang, C., Avestruz, C., and Regier, J. (2022), "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.,* **Mendoza, I.**,* Liu, R., Pang, Z., Zhao, Z., Avestruz, C., and Regier, J. (2022). "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 (2021). "Effects of overlapping sources on cosmic shear estimation: Statistical sensitivity and pixel-noise bias". *Journal of Cosmology and Astroparticle Physics*, 2021(07), 043.

PRESENTATIONS

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

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

* Equal contribution

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)

BLOG POSTS

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/