Lucia A. Perez — Curriculum Vitae

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2023-2025: Flatiron Research Fellow, Center for Computational Astrophysics

Ongoing Research and Interests

CAMELS-SAM: constraining cosmology and marginalizing over astrophysics with machine learning, with Dr. S. Genel, Dr. F. Villaescusa-Navarrom & Dr. R. Somerville), Center for Computational Astrophysics, NYC.

Neural networks are powerful and capable of probing deep patterns in data, but must be trained carefully on large and representative data sets. In Perez et al. 2022, we developed and generated a new wing of the CAMELS project, encompassing 1000+ dark-matter only simulations of $(100\,\mathrm{h}^{-1}\,\mathrm{Mpc})^3$ and N=640^3 particles, run through the Santa Cruz semi-analytic model for galaxy formation. We used simple neural networks trained with various galaxy clustering statistics and selections, with the goal of answering: what clustering summary statistic gives the best constraints for the most important cosmological and/or astrophysical parameters? This suite of simulations offers enormous potential to many applications of machine learning in astrophysics, offering the unique intersection of large volumes; good particle resolution; very broad coverage in Ω_M, σ_8, and 3 stellar and AGN feedback parameter space; and halo catalogs and merger trees for all 100 snapshots. Ongoing work with the suite, particularly to benefit the ***Learning the Universe*** Simons Foundation collaboration, includes: expanding the SC-SAM parameters varied to better understand their effect on galaxy observables (with Z. Tremitiere), expanding the prescriptions used to generate galaxies atop merger trees, and moving towards realistic synthetic galaxies.

Understanding how uncertainties in the astrophysics of galaxies affects constraints on local primordial non-Gaussianity, with A. Barreira (Origins Fellow, Munich).

The parameter f_{NL} measures the local non-Gaussianity in the primordial energy fluctuations of the Universe, and is a key target of cosmological observations: any deviation from $f_{\mathrm{NL}} = 0$ provides key constraints on inflation, though the best constraints so far from the Cosmic Microwave Background at large-scale modes find $f_{\mathrm{NL}} = -0.9 \pm 5.1(1\sigma)$. Galaxy clustering senses f_{NL} at small scales instead, and SPHEREx hopes to constrains it to $\sigma_{f_{\mathrm{NL}}} = 1$. The galaxy power spectrum is expected to show an increased signal at the small k proportional to the product of f_{NL} and two parameters of galaxy bias, b_1 (the increase of the number of galaxies caused by mass perturbations) and b_ϕ (the increase of the number of galaxies caused by primordial potential perturbations). Constraints of f_{NL} from galaxy clustering are fully degenerate with $b_1 \times b_\phi$, and it has been shown that the assumed scaling of $b_\phi(z) = 2\delta_c(b_1(z) - 1)$, derived from the halo mass function and often used in galaxy clustering constraints for f_{NL}, is *not* accurate for robustly simulated galaxies, and depends both on the galaxy selection *and* the way that galaxies are modelled (Barreira et al. 2020, 2021). If next-generation galaxy surveys truly wish to reach $\sigma_{f_{\mathrm{NL}}} = 1$, it is imperative to reduce our ignorance around the dependence of $b_1 \& b_\phi$ on galaxy selection and models. Toward this goal, I have leveraged the CAMELS-SAM pipeline to explore how varying parameters of supernova and AGN feedback affects b_ϕ for various galaxy selections. We created separate-universe N-body only simulations of $L = 205h^{-1}$ cMpc and $N = 1280^3$, and ran 75 unique parametrizations of the SC-SAM. We are currently exploring how b_ϕ and the resulting $b_\phi(b_1)$ relationship change across the 75 galaxy models for different galaxy selections.

The Clustering of LAGER z $\approx$ 0.93 [OIII] and z $\approx$ 0.47 Hα Emitters, with Dr. S. Malhotra (+ Dr. J. Rhoads), NASA Goddard Space Flight Center.

The study of the large scale structure of galaxies—how and why they appear in clustered filaments around enormous empty regions—informs us about fundamental physics that rules dark matter and the interaction between a galaxy and its surroundings. I have measured the angular two-point correlation function and the two-dimensional Void Probability Function (VPF) of foreground Hα and [OIII] emitters in the COSMOS field of the LAGER survey. I am leveraging these measurements with theoretical models of dark matter distribution and properties to understand how ELGs are distributed within their host dark matter halos. This work will prepare us for the future clustering surveys out of *RST* and *SPHEREx* and clarify how starburst galaxies at the peak of cosmic star formation are influenced by their environment.

Relevant Research Experience

- **PreDoctoral Program at the Center for Computational Astrophysics, Flatiron Institute, New York City.** *Dr. Shy Genel, with Dr. Francisco Villaescusa-Navarro & Dr. Rachel Somerville (CCA); Fall 2020.*

  • I created 1000 N-body simulations of $(100\,h^{-1}\,\mathrm{Mpc})^3$ and N=640^3 particles exploring the hyperspace of Ω_M and σ_8, and ran all through the Santa Cruz SAM while varying three parameters for galaxy outflow and AGN feedback.
  • Measured various clustering statistics under various galaxy selections, and tested how simple deep neural networks are able to predict underlying cosmological and galaxy formation parameters using these statistics.

- **La Serena School for Data Science, La Serena, Chile.** *Drs. Matthew Graham (Caltech), Amelia Bayo (U. de Valparaiso), Mauricio Cerda (U. Chile); Aug 19 - 29, 2018.*

  • Practiced implementing statistical regression, (un)supervised machine learning, deep learning, databases, high performance computing, and image processing in the context of big astronomical data.
  • Led a group project implementing supervised and unsupervised machine learning to a catalog of possible variable stars from the Asteroid Terrestrial-Impact Last Alert System.

- **LOFAR Collaboration, Hamburg, Germany** *Drs. Evan Scannapieco and Chris Groppi. (ASU)*

  • Imaged and analyzed magnetic field signatures of M51 using the new LOFAR software FACTOR at 143 MHz, 9 arcsecond resolution, and noise levels around 125 μJy.

- **Fulbright Fellowship at North West University, Mafikeng, South Africa** *Dr. Thebe Medupe*

  • Fourier analysis of archived SuperWASP light curves in search of pulsating A-type stars
  • Mentor for the NAAO Winter School, which brings 50 young black South African physics students to carry out astronomy projects and learn about their country's astronomical resources and history

- **Pacific Northwest National Laboratory** *Jeter Hall*

  • Electrical engineering and modeling for detector technology for Super Cryogenic Dark Matter Search
  • Optimizing and testing HEMT circuit to improve the detector technologies

Education

Arizona State University, Astrophysics PhD, GPA: 4.00 / 4.00

Defended April 2022. "The Void Clustering of Ly-Alpha Emitters as a Probe of Reionization."

Wellesley College: B.A. in Astrophysics, 2010. GPA: 3.55 / 4.00

Talks and Presentations (abridged)

- Dissertation talk at AAS240, June 2022. *Constraining cosmology and reionization with the Void Probability Function, feat. the new CAMELS-SAM suite for machine learning.*
- Presentation at ASU's SESE Colloquium, 17 November 2021. *Constraining Reionization with the Void Clustering of Lyman-α Emitters.*
- Presentation at the 2020 WFIRST Jamboree, 2 March 2020, Flatiron Institute. *Probing Patchy Reionization with the Void Probability Function in the era of WFIRST.*
- ComSciCon-AIP 2019, A Communicating Science Workshop for Graduate Students, 23-24 September 2019, American Institute of Physics in College Park, MD.
- Presentation at the 2019 COSMOS Team Meeting, 14–17 May 2019, Flatiron Institute. *The Clustering of LAGER z $\approx$ 0.9 [OIII] and z $\approx$ 0.4 Hα Emitters in the COSMOS field.*
- Plenary speaker, Conference for Undergraduate Women in Physics, January 2018. *Reframing Struggle and Failure.*

Teaching and Outreach (abridged)

- *Ongoing* Working with Dr. Viviana Acquaviva (CUNY, Simons Foundation) to translate her 'Machine Learning for Physics and Astronomy' course into Spanish; includes lecture slides, Python notebooks, and video lectures.

- *Spring 2023* Guest lecturer for Prof. Kelle Cruz's *Astro 100* class at Hunter College. Topics covered: Moon Phases & Eclipses, The Copernican & Keplerian Revolutions, and an overview of Cultural Astronomy.
- *Within 2017-2022* Teaching assistant for two semesters. In fall 2017, I worked with Dr. Alyssa Rhoden to help create assignments, guide lectures, grade, and interface for a class of 300 introductory astronomy students. In spring 2018, I worked with Dr. Jennifer Patience to run three sections of an introductory astronomy lab for a class of 60 astrophysics majors, in which I was responsible for teaching and grading each lesson.
- *August 2017* Academic facilitator with SunDial. Sundial is an ASU early start program for incoming Physics and SESE first year students that focuses on helping them build a community in college, as well as learn and complete a short project about exoplanet science. I led lessons covering the Stefan-Boltzmann law and coarsely deriving planets' temperatures, as well as conversations about impostor syndrome and mental health. I guided four students through a Python coding project analyzing Kepler light curves to derive exoplanet properties.
- *September 2016-Spring 2018* Telescope operator with the SESE Open Houses and Night of the Open Door, in which I help set up and take down our telescopes, help manage crowds, and share astronomy with the public.

Lucia A. Perez — Publications

- **Perez et al. 2023, in press for the Astrophysical Journal, arXiv:2304.01837.**
  Constraints on the Epoch of Reionization with Roman Space Telescope and the Void Probability Function of Lyman-α Emitters.
- **Perez et al. 2022. 2022ApJ...940..102P.**
  Probing Patchy Reionization with the Void Probability Function of Lyman-α Emitters.
- **Perez, Genel, et al. 2022, submitted to the Astrophysical Journal, in final stages of review.**
  CAMELS-SAM: new simulations for constraining cosmology with galaxy clustering and machine learning
- **Perez et al. 2021. 2021ApJ...906...58P.**
  The Void Probability Function of simulated surveys of high-redshift Lyman-α Emitters.
- CAMELS collaboration co-authorships:
  - *The CAMELS Multifield Dataset: Learning the Universe's Fundamental Parameters with Artificial Intelligence*, 2022ApJS..259...61V, Villaescusa-Navarro, et al. 2022, due to my development of the CAMELS-SAM wing of the dataset.
  - *The CAMELS Project: Public Data Release*, arXiv:2201.01300, Villaescusa-Navarro, et al. 2022, releasing CAMELS-SAM to the public.
- LAGER collaboration co-authorships:
  - *New Spectroscopic Confirmations of Ly-α Emitters at $z \sim 7$ from the LAGER Survey*, Harish et al. 2022, in which I helped visually confirm candidate LAEs for spectroscopic follow-up.
  - *The Latest LAGER Cosmic Reionization Results: The 10 deg^2 Lyα Luminosity Function at z=6.9*, Wold et al. 2021, in which I helped visually confirm candidate LAEs for spectroscopic follow-up.
  - *A Lyman-α protocluster at redshift 6.9*, Hu et al. 2021.
  - *A large, deep 3 deg^2 survey of Hα, [O III], and [O II] emitters from LAGER: constraining luminosity functions*, Khostovan et al. 2020. I and one other graduate student carried out the ELG selection based on COSMOS2015 photometric redshifts.
  - *Physical Correlations of Hα Equivalent Width Distribution: Real or Driven by Selection Effects?* Khostovan et al. in press, which uses the sample of Hα emitters I helped select in the LAGER COSMOS field.
  - *The Lyα Luminosity Function and Cosmic Reionization at $z \approx 7.0$: A Tale of Two LAGER Fields*, Hu et al. 2019.
  - *Design for the First Narrowband Filter for the Dark Energy Camera: Optimizing the LAGER Survey for z$\approx$7 Galaxies*, Zheng et al. 2019.
- Other Co-authorships:
  - *A Comprehensive Study of Hα Emitters at $z \approx 0.62$ in the DAWN Survey: The Need for Deep and Wide Regions*, Harish et al. 2020, assisted with finalizing the Hα emitter selection and general publication support.
  - *Calibrating the relation of low-frequency radio continuum to star formation rate at 1 kpc scale with LOFAR*, Heesen et al. 2019. I calibrated and processed the LOFAR data that created the 145 MHz image of NGC 5194 in Fig. 2a.