Henry Honglei Zheng

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Education

Stanford University – 3.8 GPA — Stanford, US
Physics Ph.D, Advisors: Leonardo Senatore, Eva Silverstein — Sep 2019 – Present
Thesis title: Cosmology with the Effective Theory of Large Scale Structures

University of Chicago – 3.7 GPA — Illinois, US
B.A. Physics with Honors — Sep 2015 –Jun 2019

Technical Skills

Programming Python, Rust, LaTeX, Mathematica, Tensorflow, Pytorch, Huggingface, JAX, Cython
Statistics & Modeling transformers, mechanistic interpretability, Bayesian inference, emulators

Research Experience

Supervised Program for Alignment Research 2025 — Feb 2025 – Present

- Under mentor Yuxiao Li: Developing a hybrid variational autoencoder and sparse autoencoder framework for small language models with goal of maintaining high interpretability and scalability.

Graduate Researcher, SITP and KIPAC — Sep 2019 – Present

- Developing and implementing the theory of bias and prior volume effect correction in cosmological Bayesian analysis resulting from noisy data and model misspecification (Paper in progress).
- Developing an emulator of PyBird, a python code for computing one-loop EFT predictions of two and three point correlators with application to various JAX based samplers (Paper in progress).
- Constructing a new method of solving partial differential equations using large language models with scalable inference time compute.
- Developed theory of a new Hamiltonian based optimizer using energy conserving descent and performing benchmarking on small-scale transformers with pre-training using high-quality physics datasets [5].
- Reduced uncertainty from weight initialization of small MLP models used to reweight phase space distributions in LHC jet physics data using new optimization algorithm [5].
- Evaluation of future cosmological survey's neutrino sensitivity robustness by comparing mass bounds of fisher forecasts under various ΛCDM extensions [6].
- Forecasting next generation galaxy surveys DESI and MegaMapper's cosmological parameter constraints with Fisher methodology. Constructed theoretically motivated priors that improve constraints on hard-to-measure non-Gaussianities by a factor of 2 [3].
- Developed an algorithm for solving generic one-loop QFT integrals with complex masses in 3d. Optimized in both Cython and in Rust to achieve $\mathcal{O}(1000)$ times speedup compared to FFTLog when applied to the one-loop bispectrum in the EFTofLSS [1].
- Built python and mathematica pipeline for Fisher analysis to forecast cosmological parameter constraints using one-loop galaxy powerspectrum and bispectrum for future surveys such as DESI and Megamapper [3].
- Performed MCMC analysis on Stanford cluster Sherlock using a suite of data sets to constrain Rock N' Roll and Early Dark Energy models of the early universe [4].

Undergraduate Researcher, University of Chicago — Jun 2017 – Jun 2019

- Worked on high voltage (HV) electronics design, serial communication design, physics data analysis in ROOT and detector simulations using GEANT4 [2].

SULI Summer Intern, SLAC SSRL May – Sep 2017

· Modeled ion diffusion through expitaxial thin films using time series X-ray reflectivity data to measure the ion diffusion coefficient [7].

Talks and Teaching

· Galaxy meets QCD workshop: Computing the one-loop bispectrum in redshift space of galaxies

· ETH QCD Group Meeting Informal Talk: Brief Introduction to Modern Cosmology

· ETH Cosmology Group Meeting Informal Talk: Loop Integrals in EFTofLSS

· Teaching Assistant for PHYS 16, PHYS 21, PHYS 23, PHYS 25, PHYS 43, PHYS 81, and PHYS 331

Publications

[1] Charalampos Anastasiou et al. "Efficiently evaluating loop integrals in the EFTofLSS using QFT integrals with massive propagators". In: *arXiv preprint arXiv:2212.07421* (2022).

[2] A. Ball et al. "Search for millicharged particles in proton-proton collisions at s=13TeV". In: *Physical Review D* 102.3 (Aug. 2020). ISSN: 2470-0029. DOI: 10.1103/physrevd.102.032002. URL: http://dx.doi.org/10.1103/PhysRevD.102.032002.

[3] Diogo Braganca et al. "Peeking into the next decade in Large-Scale Structure Cosmology with its Effective Field Theory". In: (July 2023). arXiv: 2307.04992 [astro-ph.CO].

[4] Guido D'Amico et al. *The Hubble Tension in Light of the Full-Shape Analysis of Large-Scale Structure Data*. 2020. arXiv: 2006.12420 [astro-ph.CO].

[5] G. Bruno De Luca et al. "Optimizers for Stabilizing Likelihood-free Inference". In: (Jan. 2025). arXiv: 2501.18419 [hep-ph].

[6] Davide Racco, Pierre Zhang, and Henry Zheng. "Neutrino masses from large-scale structures: future sensitivity and theory dependence". In: (Dec. 2024). arXiv: 2412.04959 [astro-ph.CO].

[7] Wei Wang et al. "Ultrathin Layered SnSe Nanoplates for Low Voltage, High-Rate, and Long-Life Alkali–Ion Batteries". In: *Small* 13.46 (2017).

Google Scholar Profile