Chirag Modi

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https://github.com/modichirag

Positions

Flatiron Institute — New York, NY *October 2020–Present*

Flatiron Research Fellow
Center for Computational Astrophysics
Center for Computational Mathematics

University of California — Berkeley, CA *August 2020–October 2020*

Postdoctoral Fellow
Berkeley Center for Cosmological Physics
Department of Physics

Education

University of California, Berkeley — Berkeley, CA *Fall 2014 – Summer 2020*

Ph.D. student in Physics August 2020
Advisor: Uroš Seljak *GPA: 3.887/4.0*
Thesis: Reconstruction of Cosmological Fields in Forward Model Framework
Master of Arts in Physics May, 2017

Indian Institute of Technology Bombay — Mumbai, India *Fall 2010 – Spring 2014*

Bachelor of Technology (with Honors) in Engineering Physics *CPI: 9.64/10*
Bachelor of Technology (Minor) in Statistics
Silver Medal, Graduated top of the Physics Class

Research Interests

Cosmology: Large scale structures, differentiable simulations, forward-modeling approaches to analysis

Statistics: Bayesian inference, optimization, machine learning, simulations based inference

Professional Services

Learning the Universe Workshop, CCA, Flatiron Institute August 2021
Organized a workshop to bring together leading cosmologists and machine learning experts

Statistics and Machine Learning Discussion Group, UC Berkeley, Physics Fall 2017- Fall 2018
Founded a weekly discussion group to enhance collaboration between science and statistics community.
Later evolved to official Berkeley-wide disucssion group hosted at Berkeley Institute of Data Science.

Referee - Grants Fall, 2022
European Research Council (ERC) Starting Grant

Referee - Journals since 2017
Nature Astronomy, Physical Review Letters, Physical Review D, AAS Astrophyscial Journal (ApJ), Monthly Notices of the Royal Astronomical Society (MNRAS) & Astronomy & Computing, Journal for Cosmological Physics (JCAP), ICML

Awards and Recognitions

Lyman Spitzer, Jr. Postdoctoral Fellowship January, 2020
Department of Astrophysical Sciences at Princeton University *Declined*

Conference Travel Grants Summer, 2017 & 2018
Department of Physics, University of Califrnia, Berkeley

Institute Silver Medal Mumbai, India, 2014
Indian Institute of Technology, Bombay

World Rank 2 & Gold Medal Beijing, China, 2010
International Olympiad of Astronomy and Astrophysics

Gold Medal Hongzhou, China, 2009
International Astronomy Olympiad

DAAD WISE Scholarship- Deutscher Akademischer Austausch Dienst (DAAD) Germany, Summer, 2010
German Academic Exchange Service

All India Rank 48- Joint Entrance Examination India, 2010
Indian Institute of Technology (over 500,000 students take the exam)

KVPY Fellowship- Kishore Vaigyanik Protsahan Yojna India, 2009-2010
Government of India

NTSE Fellowship- National Talent Search Scholarship India, 2008-2010
Government of India

Teaching Experience

Seminar, Flatiron Wide Algorithms Meeting, Flatiron Institute, NY October 2021
Pedagogical talk on how to develop differentiable simulations for scientists across the Flatiron Institute

Teaching Assistant, UC Berkeley, Physics Fall 2017
Assisted in developing course - "Data science and Bayesian statistics for physical sciences"

Graduate Student Instructor, UC Berkeley, Physics Fall 2014-Fall 2015
Over 3 semesters; Courses- Mechanics and Wave Motion, Honor Sequence Course

Teaching Assistant Instructor, IIT Bombay, Physics Fall 2011-Spring 2014
Over 6 semesters; Courses- Quantum Mechanics, Modern Physics, Electricity and Magnetism

Olympiad Facilitator, OCSC- International Astronomy Olympiad, HBCSE-TIFR, India Summer 2010
Academic Training: Selection and Preparation of Indian Team for International Astronomy Olympiads

Instructor, Splash at Berkeley Fall 2015 - Fall 2017
Outreach Program: Taught courses on amateur astronomy, card games from India

Students Supervised

Tri Nguyen August 2022-present
4th year Graduate, MIT
Visiting Predoc at Flatiron, 1 paper in prep

Kwan Ngai Pok June 2022-present
2nd year Undergraduate, The Chinese University of Hong Kong
Visiting Summer intern at Flatiron, 1 peer-reviewed conference paper

Adrian Bayer April 2021-present
5th year Graduate, UC Berkeley
1 preprint submitted to JCAP. 1 more paper in prep

Max Lee October 2020-present
1st year Graduate, Columbia University
1 paper in prep

Open Source Softwares

PMWD - Particle Mesh With Derivatives : *memory efficient simulations in JAX*
https://github.com/eelregit/pmwd Co-Developer

FlowPM : *Particle Mesh simulation in TensorFlow*
https://github.com/modichirag/flowpm Main Developer

CLEFT : *Parallelized python code to Compute 1-loop real-space power spectrum of biased tracers*
https://github.com/modichirag/flowpm Sole Developer

nbodykit : *Analysis kit for large-scale structure datasets, the massively parallel way*
https://github.com/bccp/nbodykit Contributor

Publications

Led/Co-Led/Major Contributions **ArXiv Google Scholar**

First author: 12, Second author: 7, Journal papers: 12, Peer-reviewed conference papers: 3, Under Review: 3, Preprint: 3

21. Forecasting the power of Higher Order Weak Lensing Statistics with automatically differentiable simulations
Lanzieri D., Lanusse F., ***Modi C.****, Horowitz B.* Under review in LSST-DESC

20. Differentiable Cosmological Simulation with Adjoint Method
Li Y., ***Modi C.****, et.al. (arXiv:2211.09815)* Submitted to JCAP

19. pmwd: A Differentiable Cosmological Particle-Mesh N-Body Library
Li Y., Lu L., ***Modi C.****, et.al. (arXiv:2211.09958)* Submitted to JOSS

18. Emulating cosmological growth functions with B-Splines
Kwan N.P., ***Modi C.****, Li Y., Ho S. (arXiv:2211.06564)* NeurIPS-ML4Science 2022

17. Joint velocity and density reconstruction of the universe with nonlinear differentiable forward modeling
Bayer A., ***Modi C.****, Ferraro S. (arXiv:2210.15649)* Submitted to JCAP

16. Reconstructing the Universe with Variational Self Boosted Sampling *Spotlight Talk*
Modi C.*, Li, Y., Blei, D. (arXiv: 2206.15433)* ICML-ML4Astro 2022

15. Delayed Rejection Hamiltonian Monte Carlo for Multi-Scale Distributions
Modi C.*, Barnett A., Carpenter B. (arXiv:2110.00610)* Submitted to Bayesian Analysis

14. CosmicRIM : Reconstructing Early Universe by Combining Differentiable Simulations with Recurrent Inference Machines
Modi C.*, Lanusse F., Seljak U., Spergel D.N., Perreault-Levasseur L. (arXiv:2104.12864)* ICLR-SimDL 2021

13. Estimating COVID-19 mortality in Italy early in the COVID-19 pandemic
Modi C.*, Böhm V., Ferraro S., Stein G., Seljak U. (medRxiv:20067074v2)* Nature Comm. 12,2729 (2021)

12. Mind the gap: the power of combining photometric surveys with intensity mapping
Modi C.*, White M., Castorina E., Slosar A. (arXiv:2102.08116)* JCAP 10(2021)056

11. FlowPM: Distributed TensorFlow Implementation of the FastPM Cosmological N-body Solver
Modi C.*, Lanusse F., Seljak U. (arXiv:2010.11847)* ASCOM 2021.100505

10. Simulations and Symmetries
Modi C.*, Chen S., White M. (arXiv:1910.07097)* MNRAS 492,5754 (2020)

9. Generative learning counterfactual analysis for econometrics synthetic control applications
Modi C.*, Seljak U. (arXiv:1910.07178)* Accepted to NeurIPS-CML2019

8. On the validity of the Born approximation in modeling cross correlations
Böhm V., ***Modi C.****, Castorina E. (arXiv:1910.06722)* JCAP 03(2020)045

7. Reconstructing large-scale structure with neutral hydrogen surveys
Modi C.*, White M., Slosar A., Castorina E. (arXiv:1907.02330)* JCAP 11(2019)023

6. Intensity mapping with neutral hydrogen and the Hidden Valley simulations
Modi C.*, Feng Y., White M., Castorina E. (arXiv:1904.11923)* JCAP 09(2019)024

5. Cosmological Reconstruction From Galaxy Light: Neural Network Based Light-Matter Connection
Modi C.*, Feng Y., Seljak U. (arXiv:1805.02247)* JCAP 10(2018)028

4. Modeling CMB lensing cross correlations with CLEFT
Modi C.*, White M., Vlah Z. (arXiv:1706.03173)* JCAP 08(2017)009

3. Halo Bias in Lagrangian Space: Estimators and Theoretical Predictions
Modi C.*, Castorina E., Seljak U. (arXiv:1612.01621)* MNRAS 472,3959 (2017)

2. A Fast Algorithm for Identifying Friends-of-Friends Halos
Feng Y., ***Modi C.*** *(arXiv:1607.03224)* ASCOM 20(2017)44-51

1. Local Random Potentials of High Differentiability to Model the Landscape
Battefeld T., ***Modi C.*** *(arXiv:1409.5135)* JCAP 03(2015)010

Science Collaborations (Small)

Papers in small teams of 4-10 people with regular participation and important science contribution

6. Differentiable Stochastic Halo Occupation Distribution
   *Horowitz B. , et al. (including **CM**) (arXiv:2211.03852)* submitted to JCAP
5. SimBIG: A Forward Modeling Approach To Analyzing Galaxy Clustering
   *Haan C., et al. (including **CM**) (arXiv:2211.00723)* Submitted to PNAS
4. SimBIG: Mock Challenge for a Forward Modeling Approach to Galaxy Clustering
   *Haan C., et al. (including **CM**) (arXiv:2211.00660)* Submitted to JCAP
3. Towards a non-Gaussian Generative Model of large-scale Reionization Maps
   *Lin Y., et al. (including **CM**) (arXiv:2210.14273)* NeurIPS-Ml4Science 2022
2. nbodykit: an open-source, massively parallel toolkit for large-scale structure
   *Hand N., et al. (including **CM**) (arXiv:1712.05834)* The Astronomical Journal, (Oct, 2018)
1. Towards Optimal Extraction of Cosmological Information from Non-linear Data
   *Seljak U., Aslanyan G., Feng Y., **Modi C.** (arXiv:1706.06645)* JCAP 12(2017)009

Science Collaborations (Large)

Papers as a part of science team of large survey collaborations

3. The DESI *N*-body Simulation Project II: Suppressing Sample Variance with Fast Simulations
   *Ding Z., et al. (including **CM**) (arxiv:2202.06074)* MNRAS, 514, 3308 (2022)
2. The clustering of galaxies in the completed SDSS-III Baryon Oscillation Spectroscopic Survey: Anisotropic galaxy clustering in Fourier-space
   *Beutler F., et al. (including **CM**) (arXiv:1607.03150)* MNRAS, 466, 2242 (2016)
1. The clustering of galaxies in the completed SDSS-III Baryon Oscillation Spectroscopic Survey: Baryon Acoustic Oscillations in Fourier-space
   *Beutler F., et al. (including **CM**) (arXiv:1607.03149)* MNRAS, 464, 3409, (2016)

Selected Talks

**: invited talks*

Sampling, Transport, and Diffusions, Flatiron Institute, NY	November 2022
*Origins Data Science Lab (ODSL) Seminar, Munich, Germany	October 2022
*Spotlight Talk, Machine Learning for Astrophysics, ICML 2022, Baltimore	July 2022
*Large-Scale Structure Cosmology beyond 2-Point Statistics, Summer Workshop Aspen	June 2022
*Interplay of Fundamental Physics and Machine Learning, Summer Workshop Aspen	June 2022
*Cosmology Seminar, Tata Institute of Fundamental Research, Mumbai, India	April 2022
Debating the potential of machine learning for astronomical surveys, IAP, Paris	October 2021
*Flatiron Wide Algorithms Meeting, Flatiron Institute, NY	October 2021
*Cosmology Seminar, Midwest Cosmology Network	June 2021
*Cosmology Lunch Seminar, Princeton Universtiy, NJ	May 2021
*DESI-AI Telecon, DESI Collaboration	January 2021
DESI December Meeting	December 2020
*CHORD Telecon, McGill University, Montreal, Quebec	August 2020
*Research Progress Meeting, LBNL, Berkeley, CA	April 2020
*Cosmology Seminar, Perimeter Institute, Waterloo, Canada	January 2020
*Research Progress Meeting, LBNL, Berkeley, CA	November 2019
*NERSC Data Seminar, LBNL, Berkeley, CA	November 2019
Cosmology Seminar, KIPAC, Stanford, CA	October 2019

Cosmology Lunch Seminar, Princeton/IAS, NJ — August 2019

*Machine Learning in the era of large astronomical surveys, KSPA, UC Santa Cruz, CA — July 2019

Dark Energy Spectroscopic Instrument (DESI) Collaboration Meeting, LBNL, Berkeley, CA — July 2019

Paving the way for next generation of cosmological surveys, SCA, Sesto, Italy — July 2018

Cosmology Seminar, MPA, Garching, Germany — July 2018

The Nonlinear Universe 2018, BCCP, Smartno, Slovenia — July 2018

Modeling the Extragalactic Sky, BCCP, Berkeley, CA — Jan 2018

Low Redshift Universe, Nordita, Stockholm, Sweden — July 2017

The Non Linear Universe, BCCP & CCA, Smartno, Slovenia — July 2017

DESI Lunch Talk, Lawrence Berkeley National Lab, Berkeley, CA — December 2016

Posters

Emulating cosmological growth functions with B-Splines
Machine Learning and the Physical Sciences
Workshop at 36th Conference on Neural Information Processing Systems (NeurIPS) — December 2022

CosmicRIM : Reconstructing Early Universe by Combining Differentiable Simulations with Recurrent Inference Machines
Deep Learning for Simulation
Workshop at The Ninth International Conference on Learning Representations (ICLR) — May 2021

Generative Learning of Counterfactual for Synthetic Control Applications in Econometrics
"Do the right thing": machine learning and causal inference for improved decision making Workshop
Workshop at 33rd Conference on Neural Information Processing Systems (NeurIPS) — December 2019

Quantifying and Understanding the Galaxy-Halo Connection
Kavli Institute of Theoretical Physics, UC Santa Barbara — May 2017

Prospective Graduate Student Open House
Department of Physics, UC Berkeley — March 2017 & 2018

6th Workshop on Algorithms for Modern Massive Data Sets (MMDS)
Berkeley Institute of Data Science, UC Berkeley — June 2016