Zhaozhou Li

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Work Experience

- Marie Skłodowska-Curie Fellow — Hebrew University of Jerusalem, Israel — 2023 –
- Postdoctoral Fellow — Hebrew University of Jerusalem, Israel — 2021 – 2023
- Postdoctoral Researcher — Shanghai Jiao Tong University, China — 2018 – 2021

Education

- Ph.D. in Astrophysics — Shanghai Astronomical Observatory, China — 2011 – 2017
  The Kinematics of Dark Matter Subhaloes and Its Application
  Advisors: Yipeng Jing, Donghai Zhao
- B.S. in Applied Physics — Beihang University, China — 2007 – 2011

Research Projects

Dynamics and formation of cosmic structures from the early Universe to the Local Group

- Star and galaxy formation with feedback-free starbursts at cosmic dawn
  A leading theory for high-redshift galaxy formation
- Galaxy structural evolution and diversity
  Includes breakthrough in modeling violent relaxation, a holy grail since 1967
  - Dark matter (DM) halos: dynamical structure and interplay with baryons and feedback
  - Satellite galaxies: initial orbits and mass function, tidal evolution, and fate
  - Formation of DM-deficient galaxies and ultra-diffuse/compact galaxies
- Novel dynamical modeling methods: mass and boundary of the Milky Way (MW) halo
  Promising next standard techniques; Current best MW mass estimates
- Novel robust Gaussian process for modeling binary stars in star clusters
  Cutting-edge machine learning algorithm with applications beyond astronomy

Professional Expertise

- Cosmological/isolated simulations & analysis
  Merger tree, (sub)structure finding, large-scale structure, `GADGET`, semi-analytical models
- Observational data analysis
  Analysis of survey catalogs (SDSS/BOSS, *Gaia*), modeling resolved stellar populations
- Statistics and machine learning
  Advanced Bayes, Gaussian process, robust statistics, clustering, active learning, etc
- Programming (Expert – `Python`; familiar – `C`, `Fortran`, `SQL`)
  High performance computing (parallel `Python`, `C`, `Cython`), numerical analysis (`Scipy`, `GSL`), big data reduction

Honors and Awards

- Marie Skłodowska-Curie Actions Fellowship, €200,000, Europe Commission — 2023 – 2025
- Rosenblum Award for Excellence in Astrophysics, $2,500 (travel fund), HUJI — 2022
- Second Prize of the National Mathematics Competitions for College Students, China — 2010

- First Prize of the Physics Experiment Competition for College Students, Beijing 2009
- Outstanding Freshman Scholarship, Second Prize, Beihang University 2007

Proposals and Grants

- Co-Investigator on NSF-BSF Research Grant (2307290; PI: van den Bosch; Dekel) 2024 – 2027
  Getting to the Core of Core Formation & Core Dynamics, $238,000 (BSF) + $490,000 (NSF)
  Key contributor to the theoretical basis of the proposal
- Co-Investigator on NSF-BSF Research Grant (2406558; PI: Teyssier; Dekel) 2024 – 2027
  The Origin of the Excess of Bright Galaxies at Cosmic Dawn, $233,000 (BSF) + $539,000 (NSF)
  Responsible for analysis involving semi-analytical models
- Marie Skłodowska-Curie Actions Fellowship, European Commission (101109759) 2023 – 2025
  Dark Matter Cusps and Cores by Violent Relaxation, €200,000
  Independent postdoc fellow; **proposal scored 99/100**, **top 1% of 800** proposals in physics
- Participant in Chinese Space Station Telescope Project (CMS-CSST-2021-B03) 2020 – 2022
  The Composition & Structure of the Milky Way & Local Group with CSST, ¥3.96M (∼$546,700)
  Support in dynamical modeling methods

Teaching

- Guest lecturer — Advanced Cosmology (graduate course, 4h cumulative) — HUJI — 2022S, 2023S
  Introductory lecture on galactic dynamics
- Guest instructor — Astrophysics Seminar (undergraduate training, 20h) — HUJI — 2022S
  Research training: reading, presenting, and report writing on cosmological challenges
- Lecturer/advisor — Scientific Practice Projects (high school students, 100h) — Shanghai — 2016 – 2018
  Reproducing Hubble's Law: data analysis, presentation, and report writing
- Lecturer — Intro to Astronomy (primary & middle schools, 25h) — Shanghai — 2015 – 2017
  Night sky, Earth, Moon, and Planets
- Lecturer — Workshop: Applied Python in Astronomy (4h) — Shanghai — Nov 2015
  Computation, data reduction, and visualization

Advising (graduates)

- Close advising: Qi Guo (Kavli IPMU, modeling filaments), Yarone Tokayer (Yale, halo dynamics)
- As scientific co-advisor: Yaofei He (THU, halo response to feedback), Feihong He (SJTU, subhalo evolution), Yanrui Zhou (SJTU, dynamical modeling), Axel Gross (UMN, halo structure)
- As technical co-advisor: Rui Shi (SJTU), Xiaokai Chen (SJTU), Xianguang Meng (SHAO)

Academic Service

- Referee for scientific journal: MNRAS Since 2022
- Coordinator of the astrophysics seminar at HUJI 2022 –
- LOC member of the conference *Studying the Universe with Galaxy Surveys*, Shanghai 2018
- Founder and maintainer of the AstroPython wechat discussion groups (∼1000 users) Since 2016
- Maintainer of the computing servers of the cosmology group at SHAO 2014 – 2020
- Coordinator of the cosmology journal club at SHAO and SJTU 2014 – 2016, 2018 – 2019

Outreach

- Public lecture at a book club, "Ramble under the Starry Sky" (2h), Changsha Jul 2023
- Expositor of the Open Day of Physics and Astronomy (20h), SJTU 2017 – 2019
- Volunteer guide at the Shanghai Natural History Museum 2016

- Member of the Interplanetary Immigration Agency, a near-future science fiction project Since 2014
- Co-organizer of sidewalk astronomy nights and stargazing camps (>20), Beijing 2007 – 2011

Open-source Contribution

- Personal codes cited in $\sim$70 papers across various disciplines (exoplanets, bioinformatics, agriculture, etc.)
- Selected personal software, see more at `https://syrte.github.io/code`
  - `cyper`: running `Cython` codes on the fly for high performance Python
  - `robustgp`: proposed novel Gaussian process regression for contaminated data ($\sim$20 citations)
  - `ndtest`: multi-dimensional statistical tests (incl. 2D K-S test, $>$50 citations)
  - `ParsecQuery`: querying isochrones from the PARSEC stellar evolution model
- Contributor to infrastructure libraries including `Numpy`, `Scipy`, `Cython`
- Ranking by public contribution:
  - Top 10% overall on StackOverflow, posts with $\sim$2.8M people reached
  - Top 500 in Israel on GitHub

Social Service

- Coordinator for *Voice of Flowing Hearts*, exhibition featuring photos by migrant children, Beijing 2010
- Volunteer for welfare field survey of schools for children of rural migrant workers, Beijing 2010
- Disaster volunteer of the Sichuan Earthquake (1 month), Pengzhou 2008

Seminar Talks

- Tsinghua University, China Jul 2024
- Shanghai Jiao Tong University, China Jun 2024
- Nanjing University, China Jun 2024
- Ben-Gurion University, Israel Jan 2024
- Purple Mountain Observatory, China Dec 2023
- Nanjing University, China Dec 2023
- Shanghai Normal University, China Dec 2023
- CCA, Flatiron Institute, US Oct 2023
- Yale University, US Oct 2023
- National Astronomical Observatories, China ($\times$2) Jul 2023
- Shanghai Astronomical Observatory, China Jun 2023
- University of Minnesota, US Nov 2022
- Hebrew University of Jerusalem, Israel Apr 2022
- Hebrew University of Jerusalem, Israel Mar 2021
- Kavli IPMU, University of Tokyo, Japan Sep 2020
- KIAA, Peking University, China Jun 2020
- Shanghai Astronomical Observatory, China Apl 2020
- SWIFAR, Yunnan University, China Nov 2019
- ICC, Durham University, UK Jul 2019
- Kavli IPMU, University of Tokyo, Japan Aug 2018
- Shanghai Jiao Tong University, China Nov 2017

Conference Presentations

- Cosmic Dawn Revealed by JWST: First Stars, Galaxies, and Black Holes, Santa Barbara — Aug 2024
  Feedback-free starbursts at cosmic dawn: Observable predictions for JWST
- XXXII IAU General Assembly 2024, Cape Town (remote) — Aug 2024
  Analytical insights into Dark Matter Deficient Galaxies
- Santa Cruz Galaxy Workshop (*invited*) — Jul 2024
  Analytical insights into Feedback Free Starbursts
- Santa Cruz Galaxy Workshop (*invited*) — Aug 2023
- Collaboration Workshop on Cosmology and Galaxy Formation, Shanghai (*invited*) — Jun 2023
- DDA54: Annual Meeting of the Division on Dynamical Astronomy of AAS, Remote — May 2023
  Modeling the formation of dark-matter deficient galaxies
- AI for Astronomy, Shenzhen/Online — Nov 2022
  Robust Gaussian process and its application to resolved stellar population
- Santa Cruz Galaxy Workshop (*invited*) — Aug 2022
  Modeling the Response of Halos to Gas Ejection and Tidal Stripping
- DDA53: Annual Meeting of the Division on Dynamical Astronomy of AAS, Remote — Apr 2022
  Modeling the response of dark matter haloes to gas ejection
- EAS: European Astronomical Society Annual Meeting, Online — Jul 2021
  Measuring the Milky Way mass profile from satellite galaxies kinematics
- DDA52: Annual Meeting of the Division on Dynamical Astronomy of AAS, Online — May 2021
  A novel dynamical modeling method based on the data-driven distribution function
- Guoshoujing Meeting on Galaxies and Cosmology, Hangzhou — May 2021
  The outer edges of the Milky Way halo from the motion of nearby galaxies
- Cross-Strait Symposium on Star Cluster Studies, Online — Dec 2020
  Precise determination of the main sequence of open clusters in the CMD
- Chinese Astronomical Society Annual Meeting, Online — Oct 2020
- Shanghai Assembly on Cosmology and Galaxy Formation, Shanghai — Nov 2019
  Constrain the Milky Way Mass Profile with Phase Space Distribution of Satellite Galaxies
- Galaxy Angular Momentum Alignment 2019, Shanghai — Oct 2019
  Satellite Kinematics and Milky Way Halo Mass
- The Milky Way 2019: LAMOST and Other Leading Surveys, Yichang — Oct 2019
  Measure the Milky Way Mass Profile with Satellite Galaxies in Phase Space
- Small Galaxies, Cosmic Questions, Durham (*poster talk*) — Jul 2019
  Milky Way Mass Profile from Satellite Dynamics
- Astrophysical Dynamics, Tsung-Dao Lee Institute, Shanghai — Jul 2019
- Galactic Dynamics in the Era of Large Surveys, Shanghai — Jul 2019
  Measure the Milky Way Mass Profile with Satellite Galaxies in Phase Space
- Halo and Galaxy Assembly Bias — from Theory to Observation, Shanghai — Jun 2019
  Constrain Massive Cluster Formation with SDSS
- The Life and Times of the Milky Way, Shanghai — Nov 2018
- Studying the Universe with Galaxy Surveys Revealing the Unlimited in Shanghai — Jun 2018
  Milky Way Halo Mass from Satellite Kinematics
- SHAO-PKU Bilateral Symposium, Shanghai — Aug 2017
- 11th Zhang Heng Meeting of the Chinese Astronomical Society, Guiyang — Jun 2017
  Determination of Milky Way Halo Mass from Kinematics of Satellite Galaxies

Publications

Since 2017: 35 papers (10 first author, 10 second/third author), 2 proceedings
700 citations, H=14 [ADS, arXiv, Google Scholar]

As first/second author (12)

35. Scaling Relations in the Phase Space Structure of Dark Matter Haloes
Gross, A., **Li, Z.**, and Qian, Y.-Z., 2024, arXiv:2409.00627

34. emPDF: Inferring the Milky Way mass with data-driven distribution function in phase space
Li, Z., Han, J., Wang, W., Qian, Y.-Z., Li, Q., Jing, Y., and Li, T.S., 2024, arXiv:2408.11414

33. Phase space distribution functions and energy distributions of dark matter particles in haloes
Gross, A., **Li, Z.**, and Qian, Y.-Z., 2024, MNRAS, 530, 836

32. Feedback-free starbursts at cosmic dawn: Observable predictions for JWST
Li, Z., Dekel, A., Sarkar, K.C., Aung, H., Giavalisco, M., Mandelker, N., and Tacchella, S., 2024, A&A, 690, A108

31. The response of dark matter haloes to gas ejection: CuspCore II
Li, Z., Dekel, A., Mandelker, N., Freundlich, J., François, T., 2023, MNRAS, 518, 5356

30. The outermost edges of the Milky Way halo from galaxy kinematics
Li, Z. and Han, J., 2021, ApJL, 915, L18

29. Robust Gaussian process regression based on iterative trimming
Li, Z., Li, L., and Shao, Z., 2021, Astronomy and Computing, 36, 100483

28. Orbital distribution of infalling satellite halos across cosmic time
Li, Z., Zhao, D.-H., Jing, Y.P., Han, J., and Dong, F.-Y., 2020, ApJ, 905, 177

27. Constraining the Milky Way mass profile with phase-space distribution of satellite galaxies
Li, Z., Qian, Y.-Z., Han, J., Li, T.S., Wang, W., and Jing, Y.P., 2020, ApJ, 894, 10

26. A versatile and accurate method for halo mass determination from phase-space distribution of satellite galaxies
Li, Z., Qian, Y.-Z., Han, J., Wang, W., and Jing, Y.P., 2019, ApJ, 886, 69

25. The structure finders and the subhalo population in cosmological simulations (*Review in Chinese*)
Li, Z., Han, J.-X., 2018, Progress in Astronomy, 36-3, 306 (w/ English abstract)

24. Determination of dark matter halo mass from dynamics of satellite galaxies
Li, Z., Jing, Y.P., Qian, Y.-Z., Yuan, Z., and Zhao, D.-H., 2017, ApJ, 850, 116

As coauthor with significant contributions

23. Growth of Massive Black-Holes in FFB Galaxies at Cosmic Dawn
Dekel, A., Stone, N.C., Dutta Chowdhury, D., Gilbaum, S., **Li, Z.**, Mandelker, N., and van den Bosch, F.C., 2024, arXiv:2409.18605

22. Why artificial disruption is not a concern for current cosmological simulations
He, F., Han, J., and **Li, Z.**, 2024, arXiv:2408.04470

21. How does the velocity anisotropy of halo stars, dark matter and satellite galaxies depend on host halo properties?
He, J., Wang, W., **Li, Z.**, Han, J., Rodriguez-Gomez, V., et al., 2024, arXiv:2407.14827

20. Are Odd Radio Circles virial shocks around massive galaxies? Implications for cosmic-ray diffusion in the circumgalactic medium
Yamasaki, S., Sarkar, K.C., and **Li, Z.**, 2024, MNRAS, 528, 3854

19. Efficient Formation of Massive Galaxies at Cosmic Dawn by Feedback-Free Starbursts
Dekel, A., Sarkar, K.S., Birnboim, Y., Mandelker, N., and **Li, Z.**, 2023, MNRAS, 523, 3201

18. Is the core-cusp problem a matter of perspective: Jeans Anisotropic Modeling against numerical simulations
Wang, W., Zhu, L., **Li, Z.**, Chen, Y., Han, J., He, F., Yang, X., et al., 2022, ApJ, 941, 108

17. The Universal Specific Merger Rate of Dark Matter Halos
Dong, F., Zhao, D., Han, J., **Li, Z.**, Jing, Y., and Yang, X., 2022, ApJ, 929, 120

16. A machine learning approach to infer the accreted stellar mass fractions of galaxies
Shi, R., Wang, W., **Li, Z.**, et al., 2022, MNRAS, 515, 3938S

15. Modeling Unresolved Binaries of Open Clusters in the Color-Magnitude Diagram. I. Method and Application of NGC 3532
Li, L., Shao, Z., **Li, Z.**, Yu, J., Zhong, J., and Chen, L., 2020, ApJ, 901, 49

14. The mass of our Milky Way (*Invited Review*)
Wang, W., Han, J., Cautun, M., **Li, Z.**, and Ishigaki, M.N., 2020, Science China: Physics, Mechanics & Astronomy, 63, 109801

Collaboration papers

13. The mass and redshift dependence of halo star clustering
Tan, Z., Wang, W., He, J., Zhang, Y., Rodriguez-Gomez, V., Han, J., **Li, Z.**, and Yang, X., 2024, ApJ, 976, 19

12. Inferring the mass content of galaxy clusters with satellite kinematics and Jeans Anisotropic modeling
Shi, R., Wang, W., **Li, Z.**, Zhu, L., Smith, A., Cole, S., Gao, H., Chen, X., Li, Q., and Han, J., 2024, ApJ, 973, 82

11. The true number density of massive galaxies in the early Universe revealed by JWST/MIRI
Wang, T., Sun, H., Zhou, L., Xu, K., Cheng, C., **Li, Z.**, et al., 2024, arXiv:2403.02399

10. Evidence for a Shallow Evolution in the Volume Densities of Massive Galaxies at z=4 to 8 from CEERS
Chworowsky, K., Finkelstein, S.L., Boylan-Kolchin, M., et al. (incl. **Li, Z.**), 2024, AJ, 168, 113

9. Effects of feedback-free starburst galaxies on the 21-cm signal and reionization history
Libanore, S., Flitter, J., Kovetz, E.D., **Li, Z.**, and Dekel, A., 2024, MNRAS, 532, 149

8. DESI Legacy Imaging Surveys Data Release 9: Cosmological Constraints from Galaxy Clustering and Weak Lensing using the Minimal Bias Model
Xu, H., Li, H., Zhang, J., et al. (incl. **Li, Z.**), 2023, Science China: Physics, Mechanics & Astronomy, 66, 129811

7. Unraveling the Complexity of Dwarf Galaxy Dynamics: A Study of Binary Orbital Motions
Wang, W., Zhu, L., Jing, Y., Grand, R.J.J., **Li, Z.**, et al., 2023, ApJ, 956, 91

6. Physical evolution of dark matter halo around the depletion boundary
Gao, H., Han, J., Fong, M., Jing, Y.P., and **Li, Z.**, 2023, ApJ, 953, 37

5. The growth pattern of liver metastases on MRI predicts early recurrence in patients with colorectal cancer: a multicenter study
Cai, Q., Mao, Y., Dai, S., et al. (incl. **Li, Z.**), 2022, European Radiology, 32, 7872

4. What to expect from dynamical modelling of cluster haloes - I. The information content of different dynamical tracers
Li, Q., Han, J., Wang, W., Cui, W., **Li, Z.**, and Yang, X., 2021, MNRAS, 505, 3907

3. Weak equivalence principle, swampland and H_0 tension with fast single radio bursts FRB 180924 and FRB 190523
Wang, D., **Li, Z.**, and Zhang, J., 2020, Physics of the Dark Universe, 29, 100571

2. The first constraint from SDSS galaxy-galaxy weak lensing measurements on interacting dark energy models
Zhang, J., An, R., Luo, W., **Li, Z.**, Liao, S., and Wang, B., 2019, ApJL, 875, L11

1. Fully self-consistent cosmological simulation pipeline for interacting dark energy models
Zhang, J., An, R., Liao, S., Luo, W., **Li, Z.**, and Wang, B., 2018, Phy. Rev. D, 98, 103530

Conference proceedings

2. Dynamical interaction in the stellar cluster – Evidence from binaries of NGC3532
Li, L., Shao, Z., **Li, Z.**, 2021, Joint Statistical Meetings (JSM) proceedings, 2021.317202

1. Satellite galaxies as better tracers of the Milky Way halo mass
Han, J., Wang, W., and **Li, Z.**, 2020, Galactic Dynamics in the Era of Large Surveys, IAU Symposium, 353, 109