JOSHUA S. SPEAGLE (沈佳士)

Statistical Sciences, Astronomy & Astrophysics, Dunlap Institute
University of Toronto
joshspeagle.github.io | j.speagle@utoronto.ca

RESEARCH INTERESTS

I develop methods and analyze large datasets to understand how **galaxies** like our own **Milky Way** form, behave, and evolve. This work lies in the interdisciplinary fields of **astrostatistics** and **data science** at the intersections of statistics, astronomy, and computer science.

POSITIONS

Dunlap Postdoctoral Fellow: Dunlap Institute, University of Toronto 2020-2025
Banting Postdoctoral Fellow: Statistical Sciences, University of Toronto 2020-2022
Supervisor: Gwen Eadie (joint with Astronomy & Astrophysics)

Project Academic Support Staff: Kavli IPMU, University of Tokyo 2015-2016
Supervisors: Naoki Yoshida, Alexie Leauthaud, & Kevin Bundy

EDUCATION

Harvard University: PhD in Astronomy 2016-2020
Advisers: Doug Finkbeiner, Charlie Conroy, Daniel Eisenstein, & Alyssa Goodman

Harvard University: MA in Astronomy 2016-2020
Advisers: Daniel Eisenstein & Alexie Leauthaud

Harvard University: BA in Astrophysics and Physics 2011-2015

SELECTED AWARDS & HONORS

Best Astrostatistics Student Paper Award (ASA/AIG) 2020
Eric R. Keto Prize for Best Thesis in Theoretical Astrophysics (Harvard) 2020
Banting Postdoctoral Fellowship (Canada) 2020
Department of Astronomy Teaching Award (Harvard) Spring 2018
Bok Center Certificate of Distinction in Teaching (Harvard) Spring 2017, 18; Fall 2018
NSF Graduate Research Fellowship (USA) 2016

TEACHING

I have a strong interest in education and pedagogy, with a focus on skills such as **programming, statistics, and data science**. See my **teaching statement** for additional details.

EQUITY, DIVERSITY, & INCLUSION

I am committed to improving equity, diversity, and inclusion (EDI) in the classroom, in my work, and in the wider academic community. See my **EDI statement** for additional details.

STUDENTS

I have (co-)supervised or am currently (co-)supervising a total of **8 students**.

Undergraduate

8. Ava Oveisi (CS/Physics, Toronto-Scarborough) — Summer 2020-Present
7. Sina Babaei Zadeh (Astronomy, Toronto) — Summer 2020-Present
   Co-supervised with Ted Mackereth (primary supervisor) & Lamiya Mowla
6. Alicia Savelli (Math/Education/Physics, Brock) — Summer 2020-Present
   Co-supervised with Ted Mackereth (primary supervisor)
5. Jeff Shen (Statistics/Astronomy/Math, Toronto) — Winter 2020-Present
   Co-supervised with Gwen Eadie & Norm Murray (primary supervisors)
4. Mingxuan Teng (Math/CS, Toronto) — Fall 2020-Present
3. Zhiya Lou (Math/Statistics, Toronto → Statistics, ICL) — Fall 2020-Present
   Co-supervised with Gwen Eadie
2. Alan Tu (Physics, Harvard) — Summer 2020-Summer 2021
   Co-supervised with Catherine Zucker (primary supervisor) & Gus Beane
1. Kaustav Das (Physics, IIT Kanpur → Astronomy, Caltech) — Summer 2019-Fall 2020
   Co-supervised with Catherine Zucker (primary supervisor)

PROFESSIONAL ACTIVITIES

Web Director
American Statistical Association: Astrostatistics Interest Group — 2020-present

Steering Committee Member
American Astronomical Society: Working Group on Astroinformatics & Astrostatistics — 2020-present

Session Organizer
Joint Statistical Meetings 2021: Understanding a Data-Rich Universe with Data-Driven Approaches (topic-contributed panel discussion) — August 2021

Workshop Organizer
University of Toronto: Stellar Stats Workshop — May 2021

Journal Clubs
Co-Founder: Statistics & Machine Learning Journal Club (University of Toronto) — 2020-Present
Co-Organizer: astro-ph Coffee (University of Toronto) — 2020-Present
Founder: Center for Astrophysics Machine Learning Journal Club (Harvard University) — 2017-2020

Manuscript Referee
Bayesian Analysis — 2021-Present
Journal of Open Source Software (JOSS) — 2020-Present
Astronomy & Astrophysics (A&A) — 2017-Present
Monthly Notices of the Royal Astronomical Society (MNRAS) — 2016-Present
American Astronomical Society Journals (AAS) — 2014-Present

SELECTED PRESENTATIONS

Invited

IPAM: Inference and Estimation in Gravitational Wave Astronomy Workshop — November 2021
Dynamic Nested Sampling with dynesty

GitHub Satellite 2019: Keynote Address Participant — May 2019
Invited for open-source code contributions (dynesty) in the analysis of the supermassive black hole in M87 by the Event Horizon Telescope collaboration

Harvard University: CMSA Big Data Conference — August 2018
Revealing the Milky Way's Dust-iny

Colloquia and Seminars

University of Chicago: Kavli Institute for Cosmological Physics Seminar — April 2021
Cosmological Cartography with Photometric Redshifts

CANSSI Ontario: Data Science Applied Research and Education Seminar — February 2021
Mapping the Milky Way in the Age of Gaia

University of Florida: Colloquium — September 2020
Enabling Data-Driven Discovery in the Milky Way and Beyond Using Large Astronomical Datasets

Villanova University: Colloquium — October 2019
Exploring the Galaxy Near and Far in the Age of Gaia

Harvard University: Summer Colloquium (joint with Catherine Zucker) — June 2019
Charting Nearby Molecular Clouds with Gaia: A New Map of Our Local Interstellar Medium

Max Planck Institute for Astronomy: Galaxy Coffee — April 2019
The Devil's in the Detail's: Photometric Biases in Modern Surveys

University of Cambridge: Data Intensive Science Seminar — April 2019
Mapping the 3-D Distribution of Dust in the Milky Way with Stellar Photometry

UMass Amherst: Data Science Tea — October 2017
Big Data Inference: Combining Hierarchical Bayes and Machine Learning to Improve Photometric Redshifts

Harvard University: CHASC Astrostatistics Seminar — September 2017
An Introduction to Dynamic Nested Sampling

Kavli IPMU: Astronomy Lunch Seminar — March 2016
Mapping, Visualizing, and Exploiting the Color-Redshift Relation

University of Tsukuba: Theoretical Astrophysics Seminar — August 2013
The Evolution of Star-Forming Galaxies over Cosmic Time

Contributed

Astro Hack Week 2020: Tutorial Leader — August 2020
Introduction to Bayesian Inference with Linear Regression

PUBLICATIONS

I am an author on **52 papers** that have over **3300 citations** (h-index=19). This includes:
12 papers as **(co-)lead author** with over **1100 citations** (h-index=9)
15 papers with **substantial contributions** with over **700 citations** (h-index=11)
1 paper (4 in prep.) **led by students** (in **blue**) I have (co-)supervised

Most of my papers can be found online on arxiv and ADS. My ORCID is 0000-0003-2573-9832.

In Preparation

Fowlie et al. [25 additional co-authors including **Speagle, J. S.**]
Nested Sampling for Physical Scientists

Huang, S.; Bradshaw, C.; Leauthaud, A.; Hearin, A.; Behroozi, P.; Lange, J.; Green, J.; DeRose, J.; & **Speagle, J. S.**
The Outer Stellar Mass of Massive Galaxies: A Simple Tracer of Halo Mass with Scatter Comparable to Richness and Reduced Projection Effects

Shen, J.; Eadie, G.; Murray, N.; **Speagle, J. S.**; Zaritsky, D.; & Conroy, C.
Estimating the Mass Distribution of the Milky Way with Bayesian Multilevel Models, the No-U-Turn Sampler, and Halo Stars from the H3 Survey

Teng, M. & **Speagle, J. S.**
Simple, Data-Driven Outlier Detection in Supervised Machine Learning Applications

Lou, Z.; **Speagle, J. S.**; & Eadie, G.
Applications of Bayesian Model Selection to Simulated Globular Clusters

Tu, A. J.; Zucker, C.; Beane, A.; **Speagle, J. S.**; Goodman, A.; Alves, J.; & Faherty, J.
Characterizing the Kinematics of Young Stars in the Radcliffe Wave

(Co-)Lead Author

12. **Speagle, J. S.** et al. [20 additional co-authors], submitted to ApJ
Mapping the Milky Way in 5-D with 170 Million Stars

11. **Speagle, J. S.** et al. [20 additional co-authors], submitted to ApJ
Deriving Stellar Properties, Distances, and Reddenings from Photometry and Astrometry with brutus

10. **Portillo, S. K. N. & Speagle, J. S.**; & Finkbeiner, D. P., 2020, AJ
Photometric Biases in Modern Surveys
arxiv: 1902.02374
Press: AAS

9. **Speagle, J. S.**, 2020, MNRAS
dynesty: A Dynamic Nested Sampling Package for Estimating Bayesian Posteriors and Evidences
arxiv: 1904.02180

8. **Speagle, J. S.**, 2019
A Conceptual Introduction to Markov Chain Monte Carlo Methods
arxiv: 1909.12313

7. **Speagle, J. S.** et al. [11 additional co-authors], 2019, MNRAS
Galaxy-Galaxy Lensing in HSC: Validation Tests and the Impact of Heterogeneous Spectroscopic Training Sets
arxiv: 1906.05876

6. **Zucker, C. & Speagle, J. S.**; Schlafly, E. F.; Green, G. M., Finkbeiner, D. P.; Goodman, A. A.; & Alves, J., 2019, ApJ
A Large Catalog of Accurate Distances to Local Molecular Clouds: The Gaia DR2 Edition
arxiv: 1902.01425

5. **Speagle, J. S.** & Eisenstein, D. J., 2017, MNRAS
Deriving Photometric Redshifts with Fuzzy Archetypes and Self-Organizing Maps II. Implementation
arxiv: 1510.08080

4. **Speagle, J. S.** & Eisenstein, D. J., 2017, MNRAS
Deriving Photometric Redshifts with Fuzzy Archetypes and Self-Organizing Maps I. Methodology
arxiv: 1510.08073

3. **Speagle, J. S.**; Capak, P. L.; Eisenstein, D. J.; Masters, D. C.; & Steinhardt, C. L., 2016, MNRAS
Exploring Photometric Redshifts as an Optimization Problem: An Ensemble MCMC and Simulated Annealing-Driven Template-fitting Approach
arxiv: 1508.02484

2. **Speagle, J. S.**; Steinhardt, C. L.; Capak, P. L.; & Silverman, J. D., 2014, ApJS
A Highly Consistent Framework for the Evolution of the Star-Forming 'Main Sequence' from z~0-6
arxiv: 1405.2041

1. **Speagle, J. S.**; Kaplan, D. L.; & van Kerkwijk, M. H., 2011, ApJ
The X-ray Counterpart of the High-B Pulsar J0726-2612
arxiv: 1111.2877

Substantial Contribution

15. Johnson, B. D.; Leja, J.; Conroy, C.; & **Speagle, J. S.**, 2021, ApJ
Stellar Population Inference with Prospector
arxiv: 2012.01426

14. **Das, K. K.**; Zucker, C.; **Speagle, J. S.**; Goodman, A.; Schlafly, E. F.; Green, G. M.; Finkbeiner, D. P.; & Alves, J., 2020, MNRAS
Constraining the Distance to the North Polar Spur with Gaia DR2
arxiv: 2009.01320
Press: Quanta, CfA Science Update

13. Cargile, P. A.; Conroy, C.; Johnson, B. D.; Ting, Y.-S.; Bonaca, A.; Dotter, A.; & **Speagle, J. S.**, 2020, ApJ
MINESweeper: Spectrophotometric Modeling of Stars in the Gaia Era
arxiv: 1907.07690

12. Leja, J.; **Speagle, J. S.**; Johnson, B. D.; Conroy, C.; van Dokkum, P.; & Franx, M., 2020, ApJ
A New Census of the 0.2 < z < 3.0 Universe, Part I: The Stellar Mass Function

arxiv: 1910.04168

11. Alves, J.; Zucker, C.; Goodman, A. A.; **Speagle, J. S.**; Meingast, S.; Robitaille, T.; Finkbeiner, D. P.; Schlafly, E. F.; & Green, G. M., 2020, Nature
Discovery of a Galactic-scale gas wave in the Solar Neighborhood
arxiv: 2001.08748
Press: Official Website

10. Zucker, C.; **Speagle, J. S.**; Schlafly, E. F.; Green, G. M.; Finkbeiner, D. P., Goodman, A.; & Alves, J., 2020, A&A
A Compendium of Distances to Molecular Clouds in the Star Formation Handbook
arxiv: 2001.00591

9. Green, G. M.; Schlafly, E. F.; Zucker, C.; **Speagle, J. S.**; & Finkbeiner, D. P., 2019, ApJ
A 3D Dust Map Based on Gaia, Pan-STARRS 1 and 2MASS
arxiv: 1905.02734

8. Cook, B. A.; Conroy, C.; van Dokkum, P.; & **Speagle, J. S.**, 2019 ApJ
Measuring Star-Formation Histories, Distances, and Metallicities with Pixel Color-Magnitude Diagrams I: Model Definition and Mock Tests
arxiv: 1904.00011

7. Safarzadeh, M.; Berger, E.; Leja, J.; & **Speagle, J. S.**, 2019, ApJL
Measuring the Delay Time Distribution of Binary Neutron Stars III. Using the Individual Star Formation Histories of Gravitational Wave Event Host Galaxies in the Local Universe
arxiv: 1905.04310
Press: AAS NOVA

6. Leja, J.; Carnall, A. C.; Johnson, B. D.; Conroy, C.; & **Speagle, J. S.**, 2019, ApJ
How to Measure Galaxy Star Formation Histories II: Nonparametric Models
arxiv: 1811.03637

5. Zucker, C.; Schlafly E. F.; **Speagle, J. S.**; Green, G. M.; Portillo, S. K. N.; Finkbeiner, D. P.; & Goodman, A. A., 2018, ApJ
Mapping Distances Across the Perseus Molecular Cloud Using CO Observations, Stellar Photometry, and Gaia DR2 Parallax Measurements
arxiv: 1803.08931

4. Tanaka, M.; Coupon, J.; Hsieh, B.-C.; Mineo, S., Nishizawa, A. J.; **Speagle, J.**; Furusawa, H.; Miyazaki, S.; & Murayama, H., 2018, PASJ
Photometric Redshifts for the Hyper Suprime-Cam Subaru Strategic Program Data Release 1
arxiv: 1704.05988

3. Steinhardt, C. L.; Capak, P. L.; Masters, D. C.; & **Speagle, J. S.**, 2016, ApJ
The Impossibly Early Galaxy Problem
arxiv: 1506.01377

2. Steinhardt, C. L. & **Speagle, J. S.**, 2014, ApJ
A Uniform History for Galaxy Evolution
arxiv: 1409.2883

1. Steinhardt, C. L.; **Speagle, J. S.** et al. [22 additional co-authors], 2014, ApJL
Star Formation at 4 < z < 6 from the Spitzer Large Area Survey with Hyper-Suprime-Cam (SPLASH)
arxiv: 1407.7030
Press: JPL

Contributing Author

25. Leauthaud, A. & Amon, A. et al. [84 additional co-authors including **Speagle, J. S.**], submitted to MNRAS
Lensing Without Borders: A Blind Comparison of the Amplitude of Galaxy-Galaxy Lensing Between Independent Imaging Surveys

24. Naidu, R. P.; Conroy, C.; Bonaca, A.; Zaritsky, D; Weinberger, R.; Ting, Y.-S.; Caldwell, N., Tacchella, S.; Han, J. J.; **Speagle, J. S.**; & Cargile, P. A., submitted to ApJ
Reconstructing the Last Major Merger of the Milky Way with the H3 Survey
arxiv: 2103.03251

23. Tacchella et al. [16 additional co-authors including **Speagle, J. S.**], submitted to ApJ
Fast, Slow, Early, Late: Quenching Massive Galaxies at z ~ 0.8
arxiv: 2102.12494

22. Zucker, C.; Goodman, A. G.; Alves, J.; Shmuel, B.; Koch, E.; **Speagle, J. S.**; Foley, M.; Finkbeiner, D. P.; Leike, R.; & Enβlin, T., submitted to ApJ
On the 3D Spatial Topologies of Local Molecular Clouds

21. Nelson, E. J. et al. [24 additional co-authors including **Speagle, J. S.**], submitted to ApJ
Spatially Resolved Star Formation and Inside-Out Quenching in the TNG50 Simulation and 3D-HST Obvservations
arxiv: 2101.12212

20. Emami, R.; Hernquist, L.; Alcock, C.; Genel, S.; Bose, S.; Weinberger, R.; Vogelsberger, M.; Shen, X.; **Speagle, J. S.**; Marinacci, F.; Forbes, J. C.; & Torrey, P.., ApJ
Stellar Halo Morphology from TNG50: Twisted and Twisted-Stretched Halos
arxiv: 2012.12284

19. Bonaca, A.; Naidu, R. P.; Conroy, C.; Caldwell, N.; Cargile, P. A.; Han, J.; Johnson, B. D.; Kruijssen, J. M. D.; Myeong, G. C.; **Speagle, J. S.**; Ting, Y.-S.; & Zaritsky, D., 2021, ApJL
Orbital Clustering Identifies the Origins of Galactic Stellar Streams
arxiv: 2012.09171

18. Green, G. M.; Tschesche, L.; Rix, H.-W.; Finkbeiner, D. P.; Zucker, C.; Schlafly, E. F.; Rybizki, J.; & **Speagle, J. S.**, 2021, **ApJ**
Data-Driven Stellar Models
arxiv: 2006.16258

17. Carter, C.; Conroy, C.; Zaritsky, D.; Ting, Y.-S.; Bonaca, A.; Naidu, R. P.; Johnson, B. D.; Cargile, P. A.; Caldwell, N.; & **Speagle, J. S.**, 2021, ApJ
Ancient Very Metal-Poor Stars Associated with the Galactic Disk in the H3 Survey
arxiv: 2012.00036

16. Desprez, G. et al. [171 additional co-authors including **Speagle, J. S.**], 2020, A&A
Euclid Preparation. X. The Euclid Photometric-Redshift Challenge
arxiv: 2009.12112

15. Zaritsky, D.; Conroy, C.; Naidu, R. P.; Cargile, P. A.; Putman, M.; Besla, G.; Bonaca, A.; Caldwell, N.; Han, J. J.; Johnson, B. D.; **Speagle, J. S.**; & Ting, Y.-S., 2020, ApJL
Discovery of Magellanic Stellar Debris in the H3 Survey
arxiv: 2011.09395

14. Johnson, B. D.; Conroy, C.; Naidu, R. P.; Bonaca, A.; Zaritsky, D.; Ting, Y.-S.; Cargile, P. A.; Han, J. J.; & **Speagle, J. S.**, 2020, ApJ
A Diffuse Metal-Poor Component of the Sagittarius Stream Revealed by the H3 Survey
arxiv: 2007.14408

13. Cabrera-Ziri, I.; **Speagle, J. S.** et al. [9 additional co-authors], 2020, MNRAS
Searching for Globular Cluster Chemical Anomalies on the Main Sequence of a Young Massive Cluster
arxiv: 2004.09636

12. Bonaca, A.; Conroy, C.; Hogg, D. W.; Cargile, P. A.; Caldwell, N.; Naidu, R. P.; Price-Whelan, A. M.; **Speagle, J. S.**; & Johnson, B. D., 2020, ApJL
High-Resolution Spectroscopy of the GD-1 Stellar Stream Localizes the Perturber Near the Orbital Plane of Sagittarius
arxiv: 2001.07215

11. Huang, S.; Leauthaud, A.; Hearin, A.; Behroozi, P.; Bradshaw, C.; Ardila, F.; **Speagle, J. S.**; Tenenti, A.; Bundy, K.; Greene, J.; Sifón, C.; & Bahcall, N., 2020, MNRAS
Weak Lensing Reveals a Tight Connection Between Dark Matter Halo Mass and the Distribution of Stellar Mass in Massive Galaxies
arxiv: 1811.01139
Press: CfA Science Update

10. Namikawa, T. et al. [73 additional co-authors including **Speagle, J. S.**], 2019, ApJ
Evidence for the Cross-correlation between Cosmic Microwave Background Polarization Lensing from POLARBEAR and the Cosmic Shear from Subaru Hyper Suprime-Cam
arxiv: 1904.02116

9. Forbes, J. C.; Krumholz, M. R.; & **Speagle, J. S.**, 2019, MNRAS
Towards a Radially-Resolved Semi-Analytic Model for the Evolution of Disc Galaxies Tuned with Machine Learning
arxiv: 1810.12919

8. Hikage, C. et al. [35 additional co-authors including **Speagle, J. S.**], 2019, PASJ
Cosmology from cosmic shear power spectra with Subaru Hyper Suprime-Cam first-year data
arxiv: 1809.09148
Press: PASJ Excellent Paper Award (English)

7. Leja, J.; Johnson, B. D.; Conroy, C.; van Dokkum, P.; **Speagle, J. S.**; Brammer, G.; Momcheva, I.; Skelton, R.; Whitaker, K. E.; Franx, M; & Nelson, E. J., 2019, ApJ
An Older, More Quiescent Universe from Panchromatic SED Fitting of the 3D-HST Survey
arxiv: 1812.05608

6. Medezinski, E. et al. [15 additional co-authors including **Speagle, J. S.**], 2018, PASJ
Source Selection for Cluster Weak Lensing Measurements in the Hyper Sprime-Cam Survey
arxiv: 1706.00427

5. Mandelbaum, R. et al. [30 additional co-authors including **Speagle, J. S.**], 2018, PASJ
The first-year shear catalog of the Subaru Hyper Suprime-Cam SSP Survey
arxiv: 1706.06745

4. Aihara, H. et al. [108 additional co-authors including **Speagle, J. S.**], 2018, PASJ
First Data Release of the Hyper Suprime-Cam Subaru Strategic Program
arxiv: 1702.08449

3. Aihara, H. et al. [142 additional co-authors including **Speagle, J. S.**], 2018, PASJ
The Hyper Suprime-Cam SSP Survey: Overview and Survey Design
arxiv: 1704.05858

2. Oguri, M. et al. [24 additional co-authors including **Speagle, J. S.**], 2018, PASJ
An optically-selected cluster catalog at redshift 0.1<z<1.1 from Hyper Suprime-Cam Subaru Strategic Program S16A data
arxiv: 1701.00818

1. Masters, D. C. et al. [19 additional co-authors including **Speagle, J. S.**], 2015, ApJ
Mapping the Galaxy Color-Redshift Relation: Optimal Photometric Redshift Calibration Strategies for Cosmology Surveys
arxiv: 1509.03318