

Sarah C. Millholland

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RESEARCH INTERESTS Exoplanet detection & characterization; orbital architectures of planetary systems; planetary dynamics and celestial mechanics; exoplanet demographics

EDUCATION

Yale University, New Haven, CT July 2016 – May 2020
 Ph.D. in Astronomy, May 2020
 Thesis: Data-Driven Dynamics of Planetary Systems
 Advisor: Prof. Greg Laughlin
 M.S., M.Phil. in Astronomy, May 2018

UC Santa Cruz, Santa Cruz, CA Sept. 2015 – June 2016
 Pursuit of Ph.D. in Astronomy & Astrophysics
 (transferred after completing first year)

University of Saint Thomas, Saint Paul, MN Sept. 2011 – May 2015
 B.S. in Physics; **B.A.** in Mathematics, May 2015
 Summa Cum Laude

POSITIONS

NASA Sagan Fellow 2020 – present
Department of Astrophysical Sciences, Princeton University

NSF Graduate Research Fellow 2017 – 2020
Department of Astronomy, Yale University
Advisor: Prof. Greg Laughlin

Graduate Student Researcher 2015 – 2017
Department of Astronomy, Yale University (2016 – 2017)
Department of Astronomy & Astrophysics, UCSC (2015 – 2016)
Advisor: Prof. Greg Laughlin

Goldwater Scholar 2014 – 2015
Undergraduate Student Researcher 2012 – 2013, 2015
Department of Physics, University of St. Thomas
Advisor: Prof. Gerry Ruch

NSF REU Student Summer 2014
Harvard-Smithsonian Center for Astrophysics
REU in Solar Physics
Advisors: Dr. Antonia Savcheva and Dr. Edward DeLuca

Collaborative Inquiry Research Scholar 2014
Department of Physics, University of St. Thomas
Advisor: Prof. Marty Johnston

NSF REU Student Summer 2013
National Oceanic and Atmospheric Administration (NOAA)
REU at the Laboratory for Atmospheric and Space Physics (LASP)
Advisor: Dr. Naomi Maruyama

AWARDS	- Brouwer Prize (awarded to Yale astronomy graduate students for contributions of unusual merit to any branch of astronomy)	2021
	- Lyman Spitzer Jr. Postdoctoral Fellowship, Princeton University	2023 – 2025
	- NASA Hubble Fellowship Program (NHFP) Sagan Fellowship	2020 – 2023
	- Tinsley Award (best paper by a Yale astronomy graduate student; for Millholland & Laughlin 2017b)	2018
	- DDA/AAS Raynor L. Duncombe Prize for Student Research	2018
	- Yale Conference Travel Fellowship	2017
	- NSF Graduate Research Fellowship	2017 – 2020
	- Summer Sagan Workshop Travel Award	2016
	- UCSC Regents Fellowship	2015
	- NSF Graduate Research Fellowship Honorable Mention	2015
	- Barry M. Goldwater Scholarship (national science scholarship)	2014 – 2015
	- Smith Academic Scholarship	2014 – 2015
	- Danger Mathematics Scholarship	2013 – 2014, 2014 – 2015
	- UST Collaborative Inquiry Research Scholarship	2014
	- Walczak Mathematics Scholarship	2013 – 2014
	- B. John Barry Academic Scholarship	2012 – 2013
	- UST Endowed Scholarship	2011 – 2015
TEACHING EXPERIENCE	- Teaching Fellow, Planets and Stars, Yale University	Spring 2017
	- Teaching Fellow, Physics of Planetary Systems, UCSC	Spring 2016
	- Teaching Fellow, Overview of the Universe, UCSC	Fall 2016
	- Teaching Assistant, Modern Physics, UST	Springs 2014, 2015
	- Observatory Lab Instructor, Introduction to Astronomy, UST and the UST Observatory	Fall 2012 – Spring 2015
MENTORING EXPERIENCE	- David Jensen, Princeton University undergraduate student, 2020 – present	
	- Samantha Berek, Yale University undergraduate student (mentored through the “Astro Sib” program), 2018 – 2020	
	- Adrian Kulesza, Yale University undergraduate student (research project in “Astrophysics Research Methods”), Spring 2019	
	- Rachel Cohen, Yale University undergraduate student (research project in “Astrophysics Research Methods”), Spring 2019	
	- Marguerite Epstein-Martin, Yale University undergraduate student (co-advised with Greg Laughlin), 2017 – 2018	
REFEREED PUBLICATIONS	First author:	
	12. Millholland, S. , He, M., Ford, E., et al. “Evidence for a Non-Dichotomous Solution to the Kepler Dichotomy: Mutual Inclinations of Kepler Planetary Systems from Transit Duration Variations.” 2021, AAS Journals, submitted	
	11. Millholland, S. & Spalding, C. “Formation of Ultra-Short-Period Planets by Obliquity-Driven Tidal Runaway.” 2020, ApJ, 905, 71	
	10. Millholland, S. , Petigura, E., & Batygin, K. “Tidal Inflation Reconciles Low-Density Sub-Saturns with Core Accretion.” 2020, ApJ, 897, 7	
	9. Millholland, S. “Tidally Induced Radius Inflation of Sub-Neptunes.” 2019, ApJ, 886, 72	
	8. Millholland, S. & Batygin, K. “Excitation of Planetary Obliquities Through Planet-Disk Interactions.” 2019, ApJ, 876, 119	

7. **Millholland, S.** & Laughlin, G. “Obliquity-Driven Sculpting of Exoplanetary Systems.” 2019, *Nature Astronomy*, 3, 424, arXiv: 1903.01386
6. **Millholland, S.** & Laughlin, G. “Obliquity Tides May Drive WASP-12b’s Rapid Orbital Decay.” 2018, *ApJL*, 869, L15
5. **Millholland, S.**, Laughlin, G., Teske, J., et al. “New Constraints on Gliese 876 – Exemplar of Mean-Motion Resonance.” 2018, *AJ*, 155, 106
4. **Millholland, S.**, Wang, S., & Laughlin, G. “*Kepler* Multi-Planet Systems Exhibit Unexpected Intra-system Uniformity in Mass and Radius.” 2017, *ApJL*, 849, L33
3. **Millholland, S.** & Laughlin, G. “Supervised Learning Detection of Sixty Non-Transiting Hot Jupiter Candidates.” 2017, *AJ*, 154, 83
2. **Millholland, S.** & Laughlin, G. “Constraints on Planet Nine’s Orbit and Sky Position within a Framework of Mean-motion Resonances.” 2017, *AJ*, 153, 91
1. **Millholland, S.**, Wang, S., & Laughlin, G. “On the Detection of Non-Transiting Hot Jupiters in Multiple Planet Systems.” 2016, *ApJL*, 823, L7

Second author:

3. Lillo-Box, J., **Millholland, S.**, & Laughlin, G. “Follow-up of Non-Transiting Planets Detected by *Kepler*: Confirmation of Three Hot Jupiters and Validation of Three Other Planets.” 2021, *A&A*, submitted
2. Spalding, C. & **Millholland, S.** “Stellar Oblateness versus Distant Giants in Exciting *Kepler* Planet Mutual Inclinations.” 2020, *AJ*, 160, 105
1. Adams, A. D., **Millholland, S.**, & Laughlin, G. “Signatures of Obliquity in Thermal Phase Curves of Hot Jupiters.” 2019, *AJ*, 158, 3

Other co-author:

5. Davis, A., Wang, S., Jones, M., Eastman, J., Günther, M., Stassun, K., et al. including **Millholland, S.** [51 total] “TOI 564 b and TOI 905 b: Grazing and Fully Transiting Hot Jupiters Discovered by TESS.” 2020, *AJ*, 160, 229
4. Bryan, M., Chiang, E., Bowler, B. P., Morley, C. V., **Millholland, S.**, Blunt, S., Ashok, K. B., Nielsen, E., Ngo, H., Mawet, D., Knutson, H. A. “Obliquity Constraints on an Extrasolar Planetary-Mass Companion.” 2020, *AJ*, 159, 181
3. Wang, S., Jones, M., Shporer, A., Fulton, B. J., Paredes, L. A., Trifonov, T., Kossakowski, D., Eastman, J., Redfield, S., Günther, M. N., Kreidberg, L., Huang, C. X., **Millholland, S.**, et al. [60 total] “HD 202772Ab: A Transiting Hot Jupiter Around a Bright, Mildly Evolved Star in a Visual Binary Discovered by TESS.” 2019, *AJ*, 157, 51
2. Becker, J. C., Khain, T., Hamilton, S. J., Adams, F. C., Gerdes, D. W., Zullo, L., Franson, K., **Millholland, S.**, et al. [66 total] “Discovery and Dynamical Analysis of an Extreme Trans-Neptunian Object with a High Orbital Inclination.” 2018, *AJ*, 156, 81
1. Janvier, M., Savcheva, A., Pariat, E., Tassev, S., **Millholland, S.**, Bommier, V., McCauley, P., McKillop, S., Dougan, F. “Evolution of Flare Ribbons, Electric Currents and Quasi-separatrix Layers During an X-class Flare.” 2016, *A&A*, 591, A141

**OBSERVING
PROGRAMS**

- Keck I, HIRESr, “Non-Transiting Hot Jupiters: Hidden Companions to Known Exoplanets”, 2020B, 2 nights, Co-I (PI: Malena Rice)
- ORM, STELLA/SES, “Radial velocity confirmation of non-transiting planets from *Kepler*” 2020B, 40 hrs, Co-I (PI: Jorge Lillo-Box)

- Keck I, HIRESr, “Non-Transiting Hot Jupiters: Hidden Companions to Known Exoplanets”, 2020A, 2 nights, Co-I (PI: Songhu Wang)
- Keck I, HIRESr, “Are Hot Jupiters Dynamically Hot?”, 2020A, 2 nights, Co-I (PI: Songhu Wang)
- Keck I, HIRESr, “Non-Transiting Hot Jupiters: Hidden Companions to Known Exoplanets”, 2019B, 4 nights, Co-I (PI: Songhu Wang)
- CAHA, CAFE, “Radial velocity confirmation of non-transiting planets from Kepler” 2019B, 5 nights, Co-I (PI: Jorge Lillo-Box)
- Keck I, HIRESr, “Do Multi-planet Systems Share Alignment with Their Parent Stars?”, 2018A, 1 night, Co-I (PI: Songhu Wang)

SEMINARS & COLLOQUIA (* = INVITED)

- * Astronomy Colloquium, University of California Los Angeles, March 2021
- * Center for Integrative Planetary Science Seminar, University of California Berkeley, March 2021
- * Exoplanets and Protoplanetary Disks Research Group Talk, Imperial College London, March 2021
- * Canadian Institute for Theoretical Astrophysics Seminar, University of Toronto, March 2021
- * Center for Astrophysical Sciences Seminar, Johns Hopkins University, Feb. 2021
- * Astronomy Seminar, Carnegie Earth and Planets Laboratory, Feb. 2021
- * Astrophysics Colloquium, Massachusetts Institute of Technology, Feb. 2021
- * Colloquium, Center for Computational Astrophysics, Flatiron Institute, Oct. 2020
- * JILA Astrophysics Seminar, University of Colorado Boulder, Oct. 2020
- * JPL Exoplanet Journal Club Talk, NASA Jet Propulsion Laboratory, Aug. 2020
- * Special Seminar, Climate and Space Sciences and Engineering, University of Michigan, Feb. 2020
- * Cosmos Seminar, The University of Texas at Austin, Oct. 2019
- * Institute for Theory and Computation Seminar, Harvard University, Oct. 2019
- Friday Lunch Time Astrophysics Seminar, University of California Santa Cruz, Oct. 2019
- Tuesday Lunch Talk, University of California Los Angeles, Oct. 2019
- Astronomy Tea Talk, California Institute of Technology, Oct. 2019
- Exoplanet Tea Talk, Massachusetts Institute of Technology, Sept. 2019
- * Planetary Lunch Seminar, Cornell University, Sept. 2019
- Astronomy Seminar, Columbia University, Sept. 2019
- Star and Planet Formation Seminar, University of Michigan, March 2019
- Exoplanet Lunch Seminar, Princeton University, Feb. 2019
- * Center for Exoplanets & Habitable Worlds Seminar, Penn State University, Feb. 2019
- * Extrasolar Planets Seminar, NASA Goddard Space Flight Center, April 2018
- * Planetary Science Seminar, California Institute of Technology, Dec. 2017
- * Stars & Planets Seminar, Harvard-Smithsonian Center for Astrophysics, Nov. 2017
- Exoplanet Pizza Lunch, Harvard-Smithsonian Center for Astrophysics, March 2017

CONFERENCE TALKS

- “Testing Obliquity-Driven Sculpting of Exoplanetary Systems with PLATO.” PLATO ESP Workshop on Planetary Interiors and System Architectures, virtual conference, November 2020
- “Formation of Ultra-Short-Period Planets by Obliquity-Driven Tidal Runaway.” 2020 NHFP Symposium, virtual conference, September 2020
- “Formation of Ultra-Short-Period Planets by Obliquity-Driven Tidal Runaway.” Division of Dynamical Astronomy Meeting, virtual conference, August 2020

- “The Role of Tidal Inflation in Explaining Sub-Saturn Structures.” Boston Area Exoplanet Science Meeting #7, virtual conference, April 2020
- “Tidally-Induced Radius Inflation of Sub-Neptunes.” Extreme Solar Systems IV, Reykjavik, Iceland, August 2019
- “Tidally-Induced Radius Inflation of Sub-Neptunes.” Emerging Researchers in Exoplanet Science (ERES) V, Cornell University, Ithaca, NY, June 2019
- “Excitation of Planetary Obliquities Through Planet-Disk Interactions.” Division of Dynamical Astronomy Meeting, Boulder, CO, June 2019
- “Obliquity Tides and their Role in Understanding the Kepler Planet Period Ratio Distribution.” Kepler & K2 Science Conference V, Glendale, CA, March 2019
- “The Surprising Role of Obliquity Tides in Short-Period Exoplanets.” Boston Area Exoplanet Science Meeting #5, Boston University, Boston, MA, January 2019
- “Consequences of Large Planetary Obliquities in Extrasolar Systems.” 2018 Connecticut Exoplanets Meeting, Wesleyan University, Middletown, CT, July 2018
- “Obliquity-Driven Sculpting of Exoplanetary Systems.” Emerging Researchers in Exoplanet Science (ERES) IV, Pennsylvania State University, State College, PA, June 2018
- “On f for 9.” Planet Nine Workshop, California Institute of Technology, Pasadena, CA, May 2018
- “On the Obliquities of Planets in Close-in, Coplanar Systems.” Division of Dynamical Astronomy Meeting, San Jose, CA, April 2018
- “New Constraints on the Multi-Resonant Planetary System, Gliese 876.” Numerical Integration Methods in Planetary Science, University of Toronto at Scarborough, Toronto, Ontario, August 2017
- “Constraints on Planet Nine in a Mean-Motion Resonant Framework.” Numerical Integration Methods in Planetary Science, University of Toronto at Scarborough, Toronto, Ontario, August 2017
- “Supervised Learning Detection of Sixty Non-Transiting Hot Jupiter Candidates.” Kepler & K2 Science Conference IV, NASA Ames Research Center, Moffett Field, CA, June 2017
- “Supervised Learning Detection of Sixty Non-Transiting Hot Jupiter Candidates.” Emerging Researchers in Exoplanet Science (ERES) III, Yale University, New Haven, CT, June 2017
- “Supervised Learning Detection of Sixty Non-Transiting Hot Jupiter Candidates.” 2017 Connecticut Exoplanets Meeting, Wesleyan University, Middletown, CT, May 2017
- “Constraints on Planet Nine in a Mean-Motion Resonant Framework.” 2017 Aspen Winter Conference, Formation and Dynamical Evolution of Exoplanets, Aspen, CO, March 2017

CONFERENCE POSTERS

- **Millholland, S.**, Petigura, E., & Batygin, K. “Tidal Inflation Reconciles Low-Density Sub-Saturns with Core Accretion.” Exoplanets III Conference, virtual conference, July 2020
- Adams, A., **Millholland, S.** & Laughlin, G. “Detecting Planet Obliquity in Thermal Phase Curves.” Summer Sagan Workshop, Pasadena, CA, July 2018
- **Millholland, S.** & Laughlin, G. “Obliquity-Driven Sculpting of Exoplanetary Systems.” Exoplanets II Conference, Cambridge, UK, July 2018
- **Millholland, S.**, Laughlin, G., Butler, P., et al. “New Dynamical Constraints on the Multi-Resonant System, GJ 876.” Summer Sagan Workshop, Pasadena, CA, July 2016
- **Millholland, S.**, Laughlin, G., Burt, J., et al. “A Search for Non-Transiting Hot Jupiters with Transiting Super-Earth Companions.” Exoplanets I Conference,

	<p>Davos, Switzerland, July 2016</p> <ul style="list-style-type: none"> - Millholland, S. & Ruch, G. “An Analysis of the Fixed Star Approximation in Transit Light Curve Models.” IAU General Assembly, Meeting #29, id.2255909, Honolulu, HI, August 2015 - Millholland, S., Savcheva, A. & DeLuca, E., “Magnetic Field Modeling of Complex, Flare Producing Active Regions.” American Geophysical Union Fall Meeting, abstract #SH13A-4079, San Francisco, CA, December 2014 - Millholland, S., Maruyama, N., Maute, A., et al. “Modeling Sudden Stratospheric Warming Events Using the Ionosphere-Plasmasphere Electrodynamics Model.” American Geophysical Union Fall Meeting, abstract #SA23A-2034, San Francisco, CA, December 2013 - Millholland, S. & Ruch, G., “Modeling and Fitting Exoplanet Transit Light Curves.” AAS Meeting #221, id.343.10, Long Beach, CA, January 2013
WEB BLOG PUBLICATIONS	<ul style="list-style-type: none"> - “Tilting Planets and Sculpting Orbits”, invited guest post by S. Millholland at <i>Nature Research Behind the Paper</i>, March 2019. (Click here to follow link.)
OUTREACH TALKS AND PUBLICATIONS	<ul style="list-style-type: none"> - Exploring Science, Yale University, New Haven, CT, August 2020 (virtual talk) - Yale Young Global Scholars Research Showcase (http://globalscholars.yale.edu), Yale University, New Haven, CT, July 2019 (talk) - Institute for Learning in Retirement, Albertus Magnus College, New Haven, CT, October 2018 (talk) - Yale Young Global Scholars Research Showcase (http://globalscholars.yale.edu), Yale University, New Haven, CT, June & July 2018 (talks) - Leitner Family Observatory & Planetarium, New Haven, CT, February 2018 (talk) - Pathways Summer Scholars Program Science Café (http://pathwayssummerscholars.yale.edu), Yale University, New Haven, CT, July 2017 (talk) - Yale Young Global Scholars Research Showcase (http://globalscholars.yale.edu), Yale University, New Haven, CT, July 2017 (talk) - Pathways Summer Scholars Enrichment Workshop (http://pathwayssummerscholars.yale.edu), Yale University, New Haven, CT, July 2017 (talk & workshop) - Yale Open Labs Science Café (http://theopenlabs.org), Yale University, New Haven, CT, April 2017 (talk) - 9th Annual Women in Leadership Conference, Yale University, New Haven, CT, February 2017 (invited panel member) - “The Search for Planet Nine”, a publication for the Hartford Courant News in Education series, <i>Science Matters!</i>, Hartford, CT, January 2017 (article) - LAMAT REU Program, UCSC, Santa Cruz, CA, July 2016 (talk) - “Reading Scientific Literature”, LAMAT REU Program, UCSC, Santa Cruz, CA, June 2016 (workshop) - Public Observing Night, University of St. Thomas Observatory, St. Paul, MN, March 2013 (talk & public observing) - Minnesota Optical Society Meeting, St. Paul, MN, March 2013 (talk)
PROFESSIONAL ACTIVITIES & SERVICE	<p>Ongoing activities</p> <ul style="list-style-type: none"> - Referee for Nature Astronomy, AJ, ApJ, ApJL, MNRAS, PASP - Member, American Astronomical Society - Member, Division of Dynamical Astronomy of the AAS - Member, Division of Dynamical Astronomy Committee

	- Mentor, Goldwater Scholar Community Mentorship Program	2021 –
	- Organizer, Princeton Planetary Dynamics Reading Group	2020 –
	Past activities	
	- External reviewer, Canada-France-Hawaii Telescope	2020
	- Scientific Organizing Committee Member, Emerging Researchers in Exoplanet Science (ERES) Conference III (Yale) and V (Cornell)	2017, 2019
	- External reviewer, OPTICON Telescope Transnational Access	2019
	- Featured subject for a University of St. Thomas television commercial	2018
	- Organizing committee, UCSC astronomy prospective student visit	2015
DIVERSITY & INCLUSION INVOLVEMENT	- Co-organizer, Seminar Series on Equity, Diversity and Inclusion for the Departments of Physics and Astrophysics at Princeton	2020
	- Committee member, Improving equity and inclusion in graduate admissions at the Department of Astrophysics at Princeton	2020
	- Organizer, Panel Discussion at Emerging Researchers in Exoplanet Science V: “Diversity & Inclusion in Astronomy”	2019
SELECTED OUTREACH	- Yale Open Labs (http://theopenlabs.org)	2016 – 2018
	- Committee chair for Science Café Talk Series	2017 – 2018
	- Executive board member	2016 – 2017
	- Organizer of Yale Young Global Scholars Program visits to the Astro. Department (http://globalscholars.yale.edu)	2017, 2018
	- Public Night Volunteer, Lick Observatory	Summer 2016
	- Astronomy Public Night Leader, UST Observatory	2012 – 2015
	- UST Math Club Vice President	2014 – 2015
	- UST Math Club Communications Administrator	2013 – 2014
	- UST Physics Club President	2012 – 2013
	- UST Student Alumni Council Member	2012 – 2013
	- UST Women’s Choir Board Member	2012 – 2013
	- UST Volunteers in Action	2011 – 2013
TUTORING EXPERIENCE	- Head Tutor (i.e. tutor and supervisor of other student tutors), Math Resource Center, UST	2015
	- Tutor of Math and Physics, Math Resource Center, UST	2012 – 2015
	- Private Tutor of Math and Physics	2013 – 2015
SELECTED MEDIA COVERAGE	- Tilted planets (Millholland & Laughlin 2019) featured in Scientific American, Sky & Telescope, Popular Science, Science Daily, Live Science, Space.com, Yale News.	
	- Intra-system uniformity (Millholland et al. 2017) featured in AAS Nova, Nature Research Highlights.	
	- Machine learning detection of hot Jupiters (Millholland & Laughlin 2017b) featured in National Geographic, Sky & Telescope, FOX 61 Connecticut News (television), University of St. Thomas News, Yale News.	