

# Ryan Keeley

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## Academic Positions

### Current Position

2021–Present **UC Merced**, *Postdoctoral Researcher*, Anna Nierenberg, Supervisor.

### Former Positions

2018–2021 **Korea Astronomy Space Science Institute**, *Postdoctoral Researcher*, Arman Shafieloo, Supervisor.

2014–2018 **University of California, Irvine**, *Graduate Research Assistant*, Prof. Kevork N. Abazajian, PI.

## Education

2008–2012 **B.S. Physics and History**, *California Institute of Technology*, Pasadena, CA, .

2012–2016 **Masters Physics**, *University of California, Irvine*, Irvine, CA.

2012–2018 **PhD Physics**, *University of California, Irvine*, Irvine, CA, Advisor: Professor Kevork Abazajian.

Thesis Title: Cosmology and Astroparticle Physics: What is Dark Matter and What is Dark Energy?; Funding: Fermi GI grant: Empirical Multiwavelength Analyses of the Milky Way's Galactic Center

## Research Interests

**Dark matter**, *What is it? How does it interact?.*

**Small Scale Structure**, *Does novel dark matter physics explain small scale anomalies.*

**Cosmological and Astroparticle phenomenology**, *Working at the interface between theory and observations.*

**Dark energy**, *Understanding the late-time acceleration of the Universe.*

**Large Scale Structure**, *How do dark matter haloes grow in the presence of beyond- $\Lambda$ CDM physics.*

**Inflation**, *What is the physics of the early Universe.*

**Statistics/Machine Learning**, *Developing and implementing model-independent/data-driven methods.*

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## International Collaborations

**Dark Energy Spectroscopic Instrument**, (*DESI*), Junior Member, <https://www.desi.lbl.gov/>.

**Vera C. Rubin Observatory**, (*LSST*), Junior Member, <https://www.lsst.org>.

**LSST Dark Energy Science Collaboration**, (*LSST-DESC*), Junior Member, <https://www.lsstdesc.org>.

**Sloan Digital Sky Survey**, (*SDSS*), Junior Member, <https://www.sdss.org>.

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## Publications

NASA/ADS [https://ui.adsabs.harvard.edu/search/q=author%3A%22Keeley%2C%20Ryan%20E.%22&sort=date%20desc%2C%20bibcode%20desc&p\\_1=0](https://ui.adsabs.harvard.edu/search/q=author%3A%22Keeley%2C%20Ryan%20E.%22&sort=date%20desc%2C%20bibcode%20desc&p_1=0).

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### Publications

- [1] Helena García Escudero, Jui-Lin Kuo, Ryan E. Keeley, and Kevork N. Abazajian. Early versus Phantom Dark Energy, Self-Interacting, Extra, or Massive Neutrinos, Primordial Magnetic Fields, or a Curved Universe: An Exploration of Possible Solutions to the  $H_0$  and  $\sigma_8$  Problems. *arXiv e-prints*, page arXiv:2208.14435, August 2022.
- [2] Seung-gyu Hwang, Benjamin L’Huillier, Ryan E. Keeley, M. James Jee, and Arman Shafieloo. How to use GP: Effects of the mean function and hyperparameter selection on Gaussian Process regression. *arXiv e-prints*, page arXiv:2206.15081, June 2022.
- [3] \*Ryan E. Keeley and Arman Shafieloo. Ruling Out New Physics at Low Redshift as a solution to the  $H_0$  Tension. *arXiv e-prints*, page arXiv:2206.08440, June 2022.
- [4] Elcio Abdalla, Guillermo Franco Abellán, Amin Aboubrahim, Adriano Agnello, Özgür Akarsu, Yashar Akrami, George Alestas, Daniel Aloni, Luca Amendola, Luis A. Anchordoqui, Richard I. Anderson, Nikki Arendse, Marika Asgari, Mario Ballardini, Vernon Barger, Spyros Basilakos, Ronaldo C. Batista, Elia S. Battistelli, Richard Battye, Micol Benetti, David Benisty, Asher Berlin, Paolo de Bernardis, Emanuele Berti, Bohdan Bilenko, Simon Birrer, John P. Blakeslee, Kimberly K. Boddy, Clecio R. Bom, Alexander Bonilla, Nicola Borghi, François R. Bouchet, Matteo Braglia, Thomas Buchert, Elizabeth Buckley-Geer, Erminia Calabrese, Robert R. Caldwell, David Camarena, Salvatore Capozziello, Stefano Casertano, Geoff C. F. Chen, Jens Chluba, Angela

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Chen, Hsin-Yu Chen, Anton Chudaykin, Michele Cicoli, Craig J. Copi, Fred Courbin, Francis-Yan Cyr-Racine, Bożena Czerny, Maria Dainotti, Guido D'Amico, Anne-Christine Davis, Javier de Cruz Pérez, Jaume de Haro, Jacques Delabrouille, Peter B. Denton, Suhail Dhawan, Keith R. Dienes, Eleonora Di Valentino, Pu Du, Dominique Eckert, Celia Escamilla-Rivera, Agnès Ferté, Fabio Finelli, Pablo Fosalba, Wendy L. Freedman, Noemi Frusciante, Enrique Gaztañaga, William Giarè, Elena Giusarma, Adrià Gómez-Valent, Will Handley, Ian Harrison, Luke Hart, Dhiraj Kumar Hazra, Alan Heavens, Asta Heinesen, Hendrik Hildebrandt, J. Colin Hill, Natalie B. Hogg, Daniel E. Holz, Deanna C. Hooper, Nikoo Hosseininejad, Dragan Huterer, Mustapha Ishak, Mikhail M. Ivanov, Andrew H. Jaffe, In Sung Jang, Karsten Jedamzik, Raul Jimenez, Melissa Joseph, Shahab Joudaki, Marc Kamionkowski, Tanvi Karwal, Lavrentios Kazantzidis, **Keeley, Ryan E.**, Michael Klasen, Eiichiro Komatsu, Léon V. E. Koopmans, Suresh Kumar, Luca Lamagna, Ruth Lazkoz, Chung-Chi Lee, Julien Lesgourgues, Jackson Levi Said, Tiffany R. Lewis, Benjamin L'Huillier, Matteo Lucca, Roy Maartens, Lucas M. Macri, Danny Marfatia, Valerio Marra, Carlos J. A. P. Martins, Silvia Masi, Sabino Matarrese, Arindam Mazumdar, Alessandro Melchiorri, Olga Mena, Laura Mersini-Houghton, James Mertens, Dinko Milaković, Yuto Minami, Vivian Miranda, Cristian Moreno-Pulido, Michele Moresco, David F. Mota, Emil Mottola, Simone Mozzon, Jessica Muir, Ankan Mukherjee, Suvodip Mukherjee, Pavel Naselsky, Pran Nath, Savvas Nesseris, Florian Niedermann, Alessio Notari, Rafael C. Nunes, Eoin Ó Colgáin, Kayla A. Owens, Emre Özülker, Francesco Pace, Andronikos Paliathanasis, Antonella Palmese, Supriya Pan, Daniela Paoletti, Santiago E. Perez Bergliaffa, Leandros Perivolaropoulos, Dominic W. Pesce, Valeria Pettorino, Oliver H. E. Philcox, Levon Pogosian, Vivian Poulin, Gaspard Poulot, Marco Raveri, Mark J. Reid, Fabrizio Renzi, Adam G. Riess, Vivian I. Sabla, Paolo Salucci, Vincenzo Salzano, Emmanuel N. Saridakis, Bangalore S. Sathyaprakash, Martin Schmaltz, Nils Schöneberg, Dan Scolnic, Anjan A. Sen, Neelima Sehgal, Arman Shafieloo, M. M. Sheikh-Jabbari, Joseph Silk, Alessandra Silvestri, Foteini Skara, Martin S. Sloth, Marcelle Soares-Santos, Joan Solà Peracaula, Yu-Yang Songsheng, Jorge F. Soriano, Denitsa Staicova, Glenn D. Starkman, István Szapudi, Elsa M. Teixeira, Brooks Thomas, Tommaso Treu, Emery Trott, Carsten van de Bruck, J. Alberto Vazquez, Licia Verde, Luca Visinelli, Deng Wang, Jian-Min Wang, Shao-Jiang Wang, Richard Watkins, Scott Watson, John K. Webb, Neal Weiner, Amanda Weltman, Samuel J. Witte, Radosław Wojtak, Anil Kumar Yadav, Weiqiang Yang, Gong-Bo Zhao, and Miguel Zumalacárregui. Cosmology intertwined: A review of the particle physics, astrophysics, and cosmology associated with the cosmological tensions and anomalies. *Journal of High Energy Astrophysics*, 34:49–211, June 2022.

- [5] \*Ryan E. Keeley and Arman Shafieloo. On the distribution of Bayesian evidence. *Monthly Notices of the Royal Astronomical Society*, 515(1):293–

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301, September 2022.

- [6] Hanwool Koo, Ryan E. Keeley, Arman Shafieloo, and Benjamin L'Huillier. Bayesian vs Frequentist: Comparing Bayesian model selection with a frequentist approach using the iterative smoothing method. *arXiv e-prints*, page arXiv:2110.10977, October 2021.
- [7] Xiaolei Li, \*Ryan E. Keeley, Arman Shafieloo, Xiaogang Zheng, Shuo Cao, Marek Biesiada, and Zong-Hong Zhu. Hubble diagram at higher redshifts: model independent calibration of quasars. *Monthly Notices of the Royal Astronomical Society*, 507(1):919–926, October 2021.
- [8] \*Ryan E. Keeley, Arman Shafieloo, Gong-Bo Zhao, Jose Alberto Vazquez, and Hanwool Koo. Reconstructing the Universe. *arXiv e-prints*, page arXiv:2010.03234, October 2020.
- [9] Hanwool Koo, Arman Shafieloo, Ryan E. Keeley, and Benjamin L'Huillier. Model selection and parameter estimation using the iterative smoothing method. *arXiv e-prints*, page arXiv:2009.12045, September 2020.
- [10] \*Ryan E. Keeley, Arman Shafieloo, Dhiraj Kumar Hazra, and Tarun Souradeep. Inflation Wars: A New Hope. *Journal of Cosmology and Astroparticle Physics*, June 2020.
- [11] Kevork N. Abazajian, Shunsaku Horiuchi, Manoj Kaplinghat, \*Ryan E. Keeley and Oscar Macias.
- [12] Kai Liao, Arman Shafieloo, \*Ryan E. Keeley, and Eric V. Linder. Determining Model-independent  $H_0$  and Consistency Tests. *Astrophysical Journal, Letters*, 895(2):L29, June 2020.
- [13] Hanwool Koo, Arman Shafieloo, Ryan E. Keeley, and Benjamin L'Huillier. Model-independent Constraints on Type Ia Supernova Light-curve Hyperparameters and Reconstructions of the Expansion History of the Universe. *Astrophysical Journal*, 899(1):9, August 2020.
- [14] Kai Liao, Arman Shafieloo, \*Ryan E. Keeley, and Eric V. Linder. A Model-independent Determination of the Hubble Constant from Lensed Quasars and Supernovae Using Gaussian Process Regression. *Astrophysical Journal, Letters*, 886(1):L23, November 2019.
- [15] \*Ryan E. Keeley, Arman Shafieloo, Benjamin L'Huillier, and Eric V. Linder. Debiasing cosmic gravitational wave sirens. *Monthly Notices of the Royal Astronomical Society*, 491(3):3983–3989, January 2020.
- [16] \*Ryan E. Keeley, Shahab Joudaki, Manoj Kaplinghat, and David Kirkby. Implications of a transition in the dark energy equation of state for the  $H_0$  and

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$\sigma_8$  tensions. *Journal of Cosmology and Astroparticle Physics*, 2019(12):035, December 2019.

- [17] Arman Shafieloo, \*Ryan E. Keeley, and Eric V. Linder. Will cosmic gravitational wave sirens determine the Hubble constant? *Journal of Cosmology and Astroparticle Physics*, 2020(3):019, March 2020.
- [18] Shahab Joudaki, Manoj Kaplinghat, \*Ryan E. Keeley, and David Kirkby. Model independent inference of the expansion history and implications for the growth of structure. *Physical Review D*, 97(12):123501, Jun 2018.
- [19] \*Ryan E. Keeley, Kevork N. Abazajian, Anna Kwa, Nicholas L. Rodd, and Benjamin R. Safdi. What the Milky Way's dwarfs tell us about the Galactic Center extended gamma-ray excess. *Physical Review D*, 97(10):103007, May 2018.
- [20] Kevork N. Abazajian and \*Ryan E. Keeley. Bright gamma-ray Galactic Center excess and dark dwarfs: Strong tension for dark matter annihilation despite Milky Way halo profile and diffuse emission uncertainties. *Physical Review D*, 93(8):083514, Apr 2016.
- [21] Manoj Kaplinghat, Ryan E. Keeley, Tim Linden, and Hai-Bo Yu. Tying Dark Matter to Baryons with Self-Interactions. *Physical Review Letters*, 113(2):021302, Jul 2014.

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## White Papers and Letters of Interest

**Report of the Topical Group on Cosmic Probes of Fundamental Physics for for Snowmass 2021**, [arxiv:2209.11726](#).

**Inflation and Dark Energy from spectroscopy at  $z > 2$** , [arxiv:1903.09208](#).

**The Next Generation of Cosmological Measurements with Type Ia Supernovae**, [arxiv:1903.05128](#).

**Messengers from the Early Universe: Cosmic Neutrinos and Other Light Relics**, [arxiv:1903.04763](#).

**Gravitational wave cosmology and astrophysics with large spectroscopic galaxy surveys**, [arxiv:1903.04730](#).

**Dark Matter Science in the Era of LSST**, [arxiv:1903.04425](#).

**Primordial Non-Gaussianity**, [arxiv:1903.04409](#).

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## Invited Talks and Conferences

August 2022 **CMB-S4 Meeting**, *No Loz H0 Soln*, University of Chicago.

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- August 2022 **IAUGA**, *On the Distribution of Bayesian Evidences*, Busan, South Korea.
- July 2022 **KASI seminar**, *Mixed Dark Matter Strong Lensing*, Daejeon, South Korea.
- July 2022 **GW workshop**, *GW distance inference cross correlation with galaxy surveys*, Online.
- July 2022 **Cosmology from Home**, *No Loz  $H_0$  Soln*, Online.
- June 2021 **UCI cosmology seminar**, *No Loz  $H_0$  Soln*, Online.
- December 2021 **Focused Workshop on Cosmology with Gravitational Waves**, *Cosmology With Lensed Quasars*, Online.
- July 2021 **American Physical Society DPF**, *Strong constraints on thermal relic dark matter from Fermi-LAT observations of the Galactic Center*, Online.
- July 2021 **Marcel Grossman**, *Strong constraints on thermal relic dark matter from Fermi-LAT observations of the Galactic Center*, Online.
- July 2021 **Marcel Grossman**, *Testing LCDM with eBOSS / SDSS*, Online.
- June 2021 **PASCOS 2021**, *Testing LCDM with eBOSS / SDSS*, Online.
- April 2021 **Korea Astronomy Machine Learning Meeting 2021**, *Gaussian Process Regression in Cosmology*, Seoul National University.
- April 2021 **Korea Astronomical Society Spring Meeting 2021**, *Testing LCDM with eBOSS / SDSS*, Online.
- February 2021 **Tehran Meeting on Cosmology at the Crossroads 2021**, *Inflation Wars: A New Hope*, Online.
- December 2020 **7th Korea-Japan Workshop on Dark Energy**, *Inflation Wars: A New Hope*, Online.
- October 2020 **Korea Astronomical Society Fall Meeting 2020**, *Model Independent Methods in Cosmology*, Online.
- September 2020 **Cosmology From Home**, *Model Independent Methods in Cosmology*, Online.
- June 2020 **Korea Astronomy and Space Science Institute Colloquium**, *Strong constraints on thermal relic dark matter from Fermi-LAT observations of the Galactic Center*, KASI, Daejeon, Korea.
- January 2020 **Dark Odyssey**, *Debiasing Gravitational Waves*, Seoul National University.
- December 2019 **6th Korea-Japan Workshop on Dark Energy**, *Transitional Dark Energy: A solution to the  $H_0$  tension*, Nagoya, Japan.
- October 2019 **Korea Astronomical Society Fall Meeting 2019**, *Pillars of the standard model of cosmology: dark energy and the cosmological constant*, KIAS, Seoul, Korea.
- September 2019 **CosKASI-ICG-NAOC-YITP Workshop 2019**, *Transitional Dark Energy: A solution to the  $H_0$  tension*.

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- August 2019 **COSMO19**, *Transitional Dark Energy: A solution to the  $H_0$  tension*, Aachen, Germany.
- July 2019 **KITP UCSB Tensions between Early and Late Universe**, *Transitional Dark Energy: A solution to the  $H_0$  tension*, Santa Barbara, CA, US.
- July 2019 **DESI Collaboration Meeting**, *Model independent methods in cosmology*, LBNL, Berkeley, CA, US.
- April 2019 **COSKASI 19**, *Transitional Dark Energy: A solution to the  $H_0$  tension*, Jeju, Korea.
- February 2019 **Korea Astronomical Society Spring Meeting**, *Model independent inference of the expansion history and implications for the growth of structure*, Busan, Korea.
- November 2018 **KIAS structure formation workshop**, *Model independent inference of the expansion history and implications for the growth of structure*, KIAS, Seoul, Korea.
- October 2018 **CosKASI-ICG-NAOC-YITP Workshop 2018**, *Model independent inference of the expansion history and implications for the growth of structure*, NAOC, Beijing, China.
- August 2018 **5th Korea-Japan Workshop on Dark Energy**, *Model independent inference of the expansion history and implications for the growth of structure*, KASI, Daejeon, Korea.
- June 2018 **Conference on the Intersection of Particle and Nuclear Physics**, *Dark Matter Interpretation of the Galactic Center Gamma Ray Excess*, Palm Springs, CA, US.
- February 2018 **Texas A&M High Energy seminar**, *What the Milky Ways Dwarfs tell us about the Galactic Center extended excess*, College Station, TX, US.
- August 2017 **TeV Particle Astrophysics conference**, *What the Milky Way's Dwarfs tell us about the Galactic Center extended excess*, OSU, Columbus, OH, US.
- July 2017 **Summer Institute for Neutrino Theory**, *Summer School*, Virginia Tech, Blacksburg, VA, US.
- January 2017 **American Physical Society - April Meeting**, *Bright gamma-ray Galactic Center excess and dark dwarfs: Strong tension for dark matter annihilation despite Milky Way halo profile and diffuse emission uncertainties*, Washington DC, US.

## Programming

### Languages

Python

C

C++

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C#

R

## Software

October 2017 **Cosmological expansion history inference using Gaussian processes**, DOI:10.5281/zenodo.999564.

April 2019 **Cosmological expansion history inference with a 1% forecasted H0 measurement using Gaussian processes**, DOI:10.5281/zenodo.3116772.

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## Teaching Experience

2022 **Principles of Pedagogy: level 2**, ongoing.

2021 **Principles of Pedagogy: level 1**.

2012–2018 **Physics Teaching Assistant**, UC, Irvine.

Taught various classes from the standard introductory labs and courses to the more specialized classes aimed at teaching physics and astronomy to non-science majors, to teaching upper division astronomy courses.

2016–2016 **Physics Instructor**, UC, Irvine.

Taught one of the introductory physics courses at UCI

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## Professional Affiliations and Service

### Local Outreach

2016–2018 **Teaching through COSMOS program at UC, Irvine.**

Taught basic cosmology and particle physics to high school students, ran demonstrations for basic kinematics concepts, and designed a cloud chamber kit appropriate for the students to build themselves.

### Mentoring

2018–2021 **CosKASI group**.

I mentored the graduate student in the Physical Cosmology group at KASI, which lead to the student writing 3 first author papers so far.

2021–Present **UC Merced group**.

I have begun mentoring two undergraduates here at UC, Merced who are interested in dark matter hunting

### Organizing Conferences

December 7–10 2020 **7th Korea-Japan Workshop on Dark Energy**, Chair of the LOC, Online.

Spring 2021 – Present **CosKASI Early Career Researcher Seminar Series**, Chair of committee, Online.

### Refereed Journals

**Physical Review Letters.**

**Physical Review D.**

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Monthly Notices of the Royal Astronomical Society.  
The Astrophysical Journal.  
European Physical Journal C.  
Universe.

#### Societies

Member of American Physical Society, (APS).  
Member of Korea Astronomical Society, (KAS).

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