

# Sukrit Ranjan

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## Professional Appointments

<b>University of Arizona</b>	<b>Assistant Professor</b>	<b>09/2022-Present</b>
Assistant Professor in Department of Planetary Sciences/Lunar and Planetary Laboratory at University of Arizona.		
<b>Northwestern University</b>	<b>CIERA Postdoctoral Fellow</b>	<b>09/2020-09/2022</b>
Center for Interdisciplinary Exploration and Research in Astrophysics prize fellow in NU Physics & Astronomy.		
<b>M.I.T.</b>	<b>SCOL Postdoctoral Fellow</b>	<b>09/2017-08/2020</b>
Simons Collaboration on the Origin of Life prize fellow in MIT Earth, Atmospheric & Planetary Sciences.		

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## Education

<b>Harvard University</b>	<b>PhD, Astronomy &amp; Astrophysics</b>	<b>May 2017</b>
PhD Thesis: “The UV Environment For Prebiotic Chemistry”. Research Exam (MA Thesis): “Characterization of 5 Hot Jupiter Atmospheres with WFC3 On HST”. Certificate in Origin of Life studies.		
<b>M.I.T.</b>	<b>SB, Physics</b>	<b>June 2010</b>
Major in Physics, minors in History and Astronomy. Elected to ΦBK and ΣΠΣ. GPA 4.93/5.00.		

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## Other Appointments

- **National Institute of Science Education and Research**, Visiting Professor. 10/21-12/21
  - **Blue Marble Space Institute of Science**, Affiliate Research Scientist. 06/20-present
  - **Indian Institute of Astrophysics**, Postdoctoral Researcher (PI: S. Sengupta). 06-08/2017.
  - **NASA Ames Research Center**, Research Associate/NASA Academy (PI: N. Cabrol). 06-08/2010.
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## Fellowships, Proposals & Grants

- **NASA Exoplanets Research Program**, “Experimental Constraints for Improving Terrestrial Exoplanet Photochemical Models (ExCITE-PM)”, Science PI, 2021, ~ \$677k.
  - **HST Guest Observer Program**, “Chromospheric and Coronal Activity in the Lowest-Mass Stars”, Co-I, 2020, 33 orbits/~ \$224k.
  - **CIERA Postdoctoral Fellowship**, 2020-2023
  - **Astrosat Cycle T01**, “M-dwarfs as Exoplanet Hosts: Coordinated Observations with HST and Astrosat in X-rays through UV”, Co-I, 2017, 15000.0 seconds.
  - **SCOL Postdoctoral Fellowship**, 2017-2020
  - **NSF Graduate Research Fellowship**, 2010-2013
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## Awards and Honors

- **NAI Early Career Scholarship**, 2018.
- **AAS Rodger Doxsey Prize**, 2017.
- **Harvard Astronomy Department Outstanding Mentor Certificate**, 2014 & 2015.
- **NAI Scholarship (International Summer School In Astrobiology)**, 2014
- **AGU Fall Meeting Outstanding Student Paper Award**, 2013.
- **Harvard University Certificate of Distinction in Teaching**, 2012.
- **NAI Scholarship (Nordic-NASA Summer School)** 2012.
- **MIT Joel Matthew Orloff Award for Outstanding Service in Physics**, 2010.

- NASA Ambassador for International Year of Astronomy, 2009.

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## Peer-Reviewed Publications (Published or Submitted)

\* = mentored or co-mentored student

### First-Author Publications

10. **Ranjan, S.**, S. Seager, Z. Zhan, D. Koll, W. Bains, J. Petkowski, J. Huang, Z. Lin, 2022. Photochemical Runaway in Exoplanet Atmospheres: Implications for Biosignatures. *The Astrophysical Journal*, 930, 131.
9. **Ranjan, S.**, C. Kufner, G. Lozano, Z. Todd, A. Haseki\*, D. Sasselov, 2022. UV Transmission in Natural Waters on Prebiotic Earth. *Astrobiology*, 22, 242.
8. **Ranjan, S.**, E. Schwieterman, C. Harman, A. Fateev, C. Sousa-Silva, S. Seager, R. Hu, 2020. Photochemistry of Anoxic Abiotic Habitable Planet Atmospheres: Impact of New H<sub>2</sub>O Cross-Sections. *The Astrophysical Journal*, 896, 2.
7. **Ranjan, S.**, Z. Todd, P. Rimmer, D. Sasselov, A. Babbin, 2019. Nitrogen Oxide Concentrations in Natural Waters on Early Earth. *Geochemistry, Geophysics, Geosystems*, 20, 2021.
6. **Ranjan, S.**, Z. Todd, J. Sutherland, and D. Sasselov, 2018. Sulfidic Anion Concentrations on Early Earth for Surficial Origins-of-Life Chemistry. *Astrobiology*, 18, 1023.
5. **Ranjan, S.**, R. Wordsworth, and D. Sasselov, 2017b. The Surface UV Environment on Planets Orbiting M-Dwarfs: Implications for Prebiotic Chemistry & Need for Experimental Follow-Up. *The Astrophysical Journal*, 843, 110.
4. **Ranjan, S.**, R. Wordsworth, and D. Sasselov, 2017a. Atmospheric Constraints on the Surface UV Environment of Mars at 3.9 Ga Relevant to Prebiotic Chemistry. *Astrobiology*, 17, 687.
3. **Ranjan, S.** and D. Sasselov, 2017. Constraints on the Early Terrestrial Surface UV Environment Relevant to Prebiotic Chemistry. *Astrobiology*, 17, 169.
2. **Ranjan, S.** and D. Sasselov, 2016. Influence of UV Radiation on the Synthesis of Prebiotic Molecules. *Astrobiology*, 16, 68.
1. **Ranjan, S.**, D. Charbonneau, J.-M. Désert, N. Madhusudhan, L. D. Deming, A. N. Wilkins, and A. M. Mandell, 2014. Atmospheric Characterization of 5 Hot Jupiters with the Wide Field Camera 3 on the Hubble Space Telescope. *The Astrophysical Journal*, 785, 148.

### Co-Author Publications

26. Huang, J., S. Seager, J. Petkowski, Z. Zhan, **S. Ranjan**, 2022. Methanol – A Poor Biosignature Gas in Exoplanet Atmospheres. *Astrophysical Journal*, 933, 6.
25. Greaves, J., P. Rimmer, A. Richards, J. Petkowski, W. Bains, **S. Ranjan**, S. Seager, D. Clements, C. Sousa-Silva, H. Fraser, 2022. Low Levels of Sulphur Dioxide Contamination of Phosphine Spectra from Venus' Atmosphere. *Monthly Notices of the Royal Astronomical Society*, 514, 2994.
24. Zhan, Z.\* , J. Huang, S. Seager, J. Petkowski, **S. Ranjan**, 2022. Organic Carbonyls are Poor Biosignature Gases in Exoplanet Atmospheres but May Generate Significant CO. *Astrophysical Journal*, 930, 133.
23. Glidden, A., S. Seager, J. Huang.\* , J. Petkowski, **S. Ranjan** 2022. Can Carbon Fractionation Provide Evidence for Aerial Biospheres in the Atmospheres of Temperate Sub-Neptunes? *Astrophysical Journal*, 930, 62.
22. Bains, W., O. Shorttle, **S. Ranjan**, P. Rimmer, J. Petkowski, J. Greaves, S. Seager, 2022. Only Extraordinary Volcanism Can Explain the Presence of Parts Per Billion Phosphine on Venus. *Proceedings of the National Academy of Sciences*, 119, e2121702119.
21. Bains, W., O. Shorttle, **S. Ranjan**, P. Rimmer, J. Petkowski, S. Seager, 2022. Constraints on the production of phosphine by Venusian volcanoes. *Universe*, 8, 54.
20. Lin, Z., S. Seager, **S. Ranjan**, T. Kozakis, L. Kaltenegger, 2022. H<sub>2</sub>-dominated Atmosphere as an Indicator of Second-Generation Rocky White Dwarf Exoplanets. *Astrophysical Journal Letters*, 925, L10.
19. Huang, J.\* , S. Seager, J. Petkowski, **S. Ranjan**, Z. Zhan, 2022. Assessment of Ammonia as a Biosignature Gas in Exoplanet Atmospheres. *Astrobiology*, 22, 171.
18. Rimmer, P., **S. Ranjan**, S. Rugheimer, 2021. Life's Origins and the Search for Life on Rocky Exoplanets. *Elements*, 17, 265. *Invited Review*.

17. Bains, W., J. Petkowski, S. Seager, **S. Ranjan**, C. Sousa-Silva, P. Rimmer, Z. Zhan, J. Greaves, A. Richards, 2022. Venusian phosphine: a 'wow!' signal in chemistry? Phosphorus, Sulfur, and Silocon and the Related Elements, 1-6.
16. Zhan, Z.\*, S. Seager, J. Petkowski, C. Sousa-Silva, **S. Ranjan**, et. al., 2021. Assessment of Isoprene as a Possible Biosignature Gas in Exoplanets with Anoxic Atmospheres. *Astrobiology*, 21, 765.
15. An, S., **S. Ranjan**, K. Yuan, X. Yang, R. Skodje, 2021. The Role of the Three Body Photodissociation Channel of Water in the Evolution of Dioxygen in Astrophysical Applications. *Physical Chemistry Chemical Physics*, 23, 9235.
14. Bains, W., J. Petkowski, S. Seager, **S. Ranjan**, et al., 2021. Phosphine on Venus Cannot be Explained by Conventional Processes. *Astrobiology*, 21, 1277.
13. Greaves, J., A. Richards, W. Bains, P. Rimmer, D. Clements, S. Seager, J. Petkowski, C. Sousa-Silva, **S. Ranjan**, et al., 2021. Reply to: Phosphine Gas in the Cloud Decks of Venus. *Nature Astronomy*, 5, 636.
12. Greaves, J., A. Richards, W. Bains, P. Rimmer, H. Sagawa, D. Clements, S. Seager, J. Petkowski, C. Sousa-Silva, **S. Ranjan**, et al., 2021. Addendum: Phosphine Gas in the Cloud Decks of Venus. *Nature Astronomy*, 5, 726.
11. Greaves, J., A. Richards, W. Bains, P. Rimmer, H. Sagawa, D. Clements, S. Seager, J. Petkowski, C. Sousa-Silva, **S. Ranjan**, et al., 2020. Phosphine Gas in the Cloud Decks of Venus. *Nature Astronomy*, 5, 655.
10. Seager, S., J. Petkowski, P. Gao, W. Bains, N. Bryan, **S. Ranjan**, J. Greaves, 2020. The Venusian Lower Atmosphere as a Depot for Desiccated Microbial Life: A Proposed Life Cycle for Persistence of the Venusian Aerial Biosphere. *Astrobiology*, <http://doi.org/10.1089/ast.2020.2244>.
9. Todd, Z, A. Fahrenbach, **S. Ranjan**, C. Magnani, J. Szostak, D. Sasselov, 2020. UV-driven deamination of cytidine ribonucleotides under planetary conditions. *Astrobiology*, 20, 878-888.
8. Guenther, M., Z. Zhan, S. Seager, P. Rimmer, **S. Ranjan**, et. al., 2020. Stellar Flares from the First TESS Data Release: Exploring a New Sample of M Dwarfs. *The Astronomical Journal*, 159, 2.
7. Sousa-Silva, C., S. Seager, **S. Ranjan**, J. J. Petkowski, Z. Zhan, R. Hu, W. Bains, 2020. On Phosphine as a Biosignature Gas in Exoplanet Atmospheres. *Astrobiology*, 20, 235.
6. Xu, J., D. Ritson, **S. Ranjan**, Z. Todd, D. Sasselov, J. Sutherland, 2018. Photochemical reductive homologation of hydrogen cyanide using sulfite and ferrocyanide. *Chemical Communications*, 54, 5566.
5. Todd, Z.\*, A. Fahrenbach, C. Magnani\*, **S. Ranjan**, A. Bjorkborn, J. Szostak, D. Sasselov, 2018. Solvated-electron production using cyanocuprates is compatible with the UV-environment on a Hadean-Archaeon Earth. *Chemical Communications*, 54, 1121.
4. Wilkins, A. N., L. D. Deming, N. Madhusudhan, A. Burrows, H. A. Knutson, P. McCullough, and **S. Ranjan**, 2014. The Emergent 1.1-1.7  $\mu\text{m}$  Spectrum of the Exoplanet CoRoT-2b as measured using the Hubble Space Telescope. *The Astrophysical Journal*, 783, 113.
3. Deming, L. D., A. Wilkins, P. McCullough, A. Burrows, J. J. Fortney, E. Agol, I. Dobbs-Dixon, N. Madhusudhan, N. Crouzet, J. Désert, R. L. Gilliland, K. Haynes, H. A. Knutson, M. Line, Z. Magic, A. M. Mandell, **S. Ranjan**, D. Charbonneau, M. Clampin, S. Seager, and A. P. Showman, 2013. Infrared Transmission Spectroscopy of the Exoplanets HD 209458b and XO-1b using the Wide Field Camera-3 On the Hubble Space Telescope. *The Astrophysical Journal*, 774, 95.
2. Cosgrove, R., M. Nicolls, H. Dahlgren, **S. Ranjan**, and R. Doe, 2010. Radar Detection of a Localized 1.4 Hz Pulsation in Auroral Plasma, Simultaneous with Pulsating Optical Emissions, During a Substorm. *Annales Geophysicae*, 28, 1961.
1. Nicolls, M. J., C. J. Heinselman, E.A. Hope, **S. Ranjan**, and M.C. Kelly, 2007. Imaging of Polar Mesosphere Summer Echoes with the 450 MHz Poker Flat Advanced Molecular Incoherent Scatter Radar. *Geophysical Research Letters*, 34, L20102.

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## Talks and Seminars

‡ = *Remote*

## Invited

- JHU/StSci Joint Astrobiology Seminar. Baltimore, MD. 03/2023.
- ETH Zurich Exoplanets & Habitability Seminar. Zurich, Switzerland<sup>‡</sup>. 12/2022.
- Simons Society of Fellows Symposium. New York, NY. 09/2022.
- Lorenz Center Workshop: “Tracing Sulfur From Molecular Clouds To The Origin of Life”. Leiden, The Netherlands. 09/2022.
- AbSciCon, Atlanta, GA. 05/2022.
- UCR Astrobiology Seminar, Riverside, CA. 03/2022.
- Purdue University Colloquium, West Lafayette, IN. 02/2022.
- University of Wisconsin Center for Origins Research Colloquium, Madison, WI. 02/2022.
- ELSI Symposium, Tokyo, JP<sup>‡</sup>. 01/2022.
- UA LPL Colloquium, Tucson, AZ. 12/2021.
- ASU SPD Journal Club, Tempe, AZ<sup>‡</sup>. 10/2022.
- First Annual Conference of the Polish Astrobiological Society: Life & Space 2021, Poland<sup>‡</sup>. 09/2021.
- Twinkle & The Next Generation of Exoplanet Scientists, UK<sup>‡</sup>. 09/2021.
- BMSIS Team Meeting Seminar, Seattle, WA<sup>‡</sup>. 09/2021.
- PCE<sub>3</sub> Seminar, Prebiotic Chemistry and Early Earth Environments Consortium (NASA RCN), USA<sup>‡</sup>. 09/2021.
- TIFR Seminar, Mumbai, India<sup>‡</sup>. 05/2021.
- JPL Seminar, Pasadena, CA<sup>‡</sup>. 03/2021.
- MIT Planetary Lunch Seminar, Cambridge, MA<sup>‡</sup>. 11/2020.
- University of Pennsylvania Astronomy Journal Club. Philadelphia, PA<sup>‡</sup>. 10/2020.
- National Institute of Science Education and Research School of Earth and Planetary Sciences Colloquium. Bhubaneswar, India<sup>‡</sup>. 10/2020.
- Harvard-Smithsonian Center for Astrophysics Exoplanet Lunch. Cambridge, MA<sup>‡</sup>. 04/2020.
- UC Davis Origins Group Seminar. Davis, CA. 11/2019.
- Exoclines 2019. Oxford, UK. 08/2019. **Keynote**.
- Northwestern University CIERA Theory Group Seminar. Evanston, IL. 04/2019.
- ELSI Seminar. Tokyo, Japan. 04/2019.
- XVth Rencontres du Vietnam: “Life3E’2019: Search for Life, From Early Earth to Exoplanets”. Quy Nhon, Vietnam. 03/2019. **Keynote**.
- Lorenz Center Workshop: “A Roadmap for Universal Life”. Leiden, The Netherlands. 10/2018.
- UC Riverside Astronomy Seminar. Riverside, CA. 10/2018.
- Goldschmidt Conference. Boston, MA. 08/2018.
- NASA GSFC SEEC “Seeds of Biomolecules” Conference. Greenbelt, MD. 04/2018.
- UMass Lowell Space Physics Seminar. Lowell, MA. 02/2018.
- MIT PICS Seminar. Cambridge, MA. 11/2017.
- Harvard-Smithsonian Center for Astrophysics Atomic and Molecular Physics Seminar. Cambridge, MA. 05/2017.
- Harvard Origins of Life Initiative Chalk Talk. Cambridge, MA. 02/2017.
- ELSI-Harvard Joint Workshop: The Chemical Origins of Life on Early Earth and Other Planetary Bodies. Cambridge, MA. 02/2015.

## Contributed

- COSPAR, Athens, Greece. 07/2022
- Exoplanets IV, Las Vegas, NV. 05/2022
- AbSciCon, Atlanta, GA. 05/2022
- Stars and Planets in the Ultraviolet: A Cross-Community Symposium<sup>‡</sup>. 05/2021.
- STScI 2021 Spring Symposium “Towards the Comprehensive Characterization of Exoplanets”<sup>‡</sup>. 04/2021.
- Northwestern University Lunch Seminar. Evanston, IL<sup>‡</sup>. 02/2021.
- SCOL Meeting. New York, NY<sup>‡</sup>. 11/2020.
- DPS 52<sup>‡</sup>. Virtual Meeting<sup>‡</sup>. 10/2020.
- Exoplanets III. Virtual Meeting<sup>‡</sup>. 07/2020.
- 236th American Astronomical Society Meeting. Virtual Meeting<sup>‡</sup>. 06/2020.
- Boston Area Exoplanet Science Meeting. Boston, MA<sup>‡</sup>. 04/2020.
- Gordon Research Conference on the Origin of Life. Galveston, TX. 01/2020.
- 235th American Astronomical Society Meeting. Honolulu, HI. 01/2020.
- Habitability: Producing Conditions Conducive to Life. Bozeman, MT. 09/2019.
- SCOL Meeting. New York, NY. 04/2019.
- CU Boulder CASA/JILA Seminar. Boulder, CO. 02/2019.
- FFAME Workshop: “Origins of Life”. Atlanta, GA. 10/2018.
- SCOL Meeting. New York, NY. 10/2018.
- COSPAR Meeting. Pasadena, CA. 07/2018.
- “Science of Early Life” Conference. Hamilton, Canada. 06/2018.
- Gordon Research Seminar. Galveston, TX. 01/2018.
- Boston Area Exoplanets Meeting. Cambridge, MA. 12/2017.
- Habitable Worlds: A System Science Workshop. 11/2017.
- SCOL Meeting. New York, NY. 11/2017.
- IIA Astrophysics Seminar. Bangalore, India. 06/2017.
- 5th ELSI International Symposium. Tokyo, Japan. 01/2017.
- American Astronomical Society Meeting. Grapevine, TX. 01/2017.
- Caltech Geoclub Seminar. Pasadena, CA. 12/2016.
- DTM Astronomy Seminar. Washington, DC. 11/2016.
- Columbia Astronomy Seminar. New York, NY. 11/2016.
- UChicago Exoplanets Group Seminar. Chicago, IL. 11/2016.
- MIT Kavli Institute Brown Bag Lunch. Cambridge, MA. 10/2016.
- NASA GISS Seminar. New York, NY. 10/2016.
- NASA GSFC Exoplanet Seminar. Greenbelt, MD. 09/2016.
- NASA Ames Space Science & Astrobiology Division Seminar. Moffett Field, CA. 09/2016
- MRC LMB Seminar. Cambridge, UK. 08/2016.
- University of St. Andrews Earth Science Seminar. St. Andrews, UK. 08/2016.
- Cornell Planetary Lunch. Ithaca, NY. 05/2016.
- Astrobiology Science Conference. Chicago, IL. 06/2015.
- AGU Fall Meeting. San Francisco, CA. 12/2013.
- AbGradCon. Montreal, Canada. 06/2013.
- XXVIIIth IAU General Assembly. Beijing, China. 08/2012.
- Extreme Solar Systems II. Jackson Hole, WY. 09/2011.

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## Teaching

- **Guest Lecturer (11/2019)**, MIT Course: “Astrobiology, Origins and Early Evolution of Life”. Cambridge, MA. 11/2019.
- **Teaching Fellow, Harvard University**. Taught (a) Celestial Navigation (2011). (b) How to Build a Habitable Planet (2012).
- **Teaching Assistant, MIT**. Taught (a) Physics 1 (Fall 2007) (b) Hands-On Astronomy: Observing Stars and Planets (Spring 2009) (c) Observational Techniques of Optical Astronomy (Fall 2009).
- **Teacher & Organizer, Observational Astronomy for High-School Students, Fall 2008, 2009**. Developed and taught evening class in observational astronomy for local high-school students. Included classroom and laboratory components and field trips.
- **Teaching Assistant, Programa Joves i Ciencia, Summer 2008, 2009**. Taught astrophysics and observational astronomy to high school students in Spain. Included classroom and laboratory components; developed own program.

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## Mentorship

### Research

- **Co-Mentor, Graduate Research**. (2) Co-mentored two graduate students in photochemistry research, resulting in first-author publications for the students (2018-2021). (1) Mentored graduate student in origins-of-life research, resulting in first-author publication for the student (2016-2018).
- **Mentor, Undergraduate Research**. (2) As visiting faculty at NISER, mentoring two undergraduates in planetary science research (2021-2022). (1) Co-supervisor & project designer for undergraduate junior and senior theses. Student co-author on peer-reviewed publication (2013-2015).
- **Mentor, High School Research**. (2) Mentored high school student in capstone project in AP Research class (2020-21). (1) Mentored high school student via Research Science Institute (RSI) program (2019). Guided student through research project; student co-author on peer-reviewed paper incorporating her work. Won “Top 5 Presentation” honor at RSI. News coverage.

### Non-Research

- **Mentor, Underrepresented Undergraduates**. (2) Professional mentor for MIT sophomore-senior undergraduates from underrepresented backgrounds via E-Mentor Advocate Partnership Program (EMAP; 2021-present) (1) Mentor for MIT freshmen from underrepresented backgrounds via Mentor Advocate Program (MAP; 2018-2020).
- **Peer Mentor**. (3) Peer mentor for junior postdocs in MIT EAPS department (2018-2020). (2) Mentor for graduate student in MIT EAPS department (2019-present). (1) Peer mentor for interns & junior graduate students in Harvard Astronomy department (2012-2015).
- **Mentor, Underrepresented High-School Students** Guided local high-school students from underrepresented backgrounds through hands-on science project via MIT SciPro program (2007).

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## Training in Pedagogy, Mentorship & Leadership

- **“Leadership Coaching Program”** (2021). Formal coaching in leadership at Northwestern.
  - **“Mentoring Up + Down”** (2021). Formal training in mentorship at Northwestern.
  - **“Inclusive Classrooms: How to Leverage Identity to Improve your Teaching Practice”** (2020). Formal training in inclusive teaching for postdocs at MIT.
  - **“Scientists Teaching Science”** (2017). Graduate course in STEM science pedagogy at Harvard (audit, full participation).
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## Service

- **Peer reviewer** for *Science*, *Nature Astronomy*, *Nature Communications*, *The Astrophysical Journal*, *AGU Advances*, *Icarus*, *Astrobiology*, *Life*.
- **Member, CIERA Astrophysics Seminar Committee (2020-2021)**
- **Interviewer, MIT Undergraduate Admissions (2011-present).**
- **Member, Department Retreat Organizing Committee (2014).** Organized inaugural retreat for Harvard Astronomy department.
- **Representative, Faculty Search Committee (2013-14).** Elected representative to Harvard Astronomy department committee to select new professor.
- **Representative, Graduate Student Council (2011-13).** Elected representative to Harvard GSC.
- **Representative, Committee on Curricula (2007-2009).** Representative to the MIT CoC.
- **Representative, Committee on the Undergraduate Program (2009).** Representative to the MIT CUP.

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## References

- **Professor Dimitar Sasselov**, Harvard University, dsasselov@cfa.harvard.edu.
- **Professor Sara Seager**, Massachusetts Institute of Technology, seager@mit.edu
- **Professor James Kasting**, Pennsylvania State University, jfk4@psu.edu
- **Professor Vicky Kalogera**, Northwestern University, vicky@northwestern.edu
- **Professor Andrew Babbín**, Massachusetts Institute of Technology, babbín@mit.edu