

## Dr. Edward M. Molter

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Nickname: Ned ♦ pronouns: he/him

Postdoctoral Scholar, Earth and Planetary Science Department, UC Berkeley

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### RESEARCH INTERESTS

Planetary atmospheres; planetary rings; radiative transfer; atmospheric dynamics; extreme weather; climate change; photochemistry; interferometry, astronomical software development

### EDUCATION

**Ph.D. Astrophysics**, University of California, Berkeley **August 2022**  
*Thesis:* “Cloud Formation and Circulation in Planetary Tropospheres from Remote-Sensing Data”  
*Advisers:* Dr. William Collins, Dr. Imke de Pater  
**M.A. Astrophysics**, University of California, Berkeley **December 2018**  
**B.A. Physics, Summa Cum Laude**, Macalester College **May 2015**  
*Thesis:* “Constraining the Properties of the Metal-Poor ISM with Interferometric CO Observations of Low Metallicity Dwarf Galaxies”  
*Adviser:* Dr. John Cannon

### RESEARCH POSITIONS

**CIPS Postdoctoral Scholar**, Dept. of Earth & Planetary Science, UC Berkeley **Sep 2022 - present**  
**Graduate Student Researcher**, Lawrence Berkeley National Lab **Aug 2019 - Aug 2022**  
*Adviser:* Dr. William Collins  
**Graduate Student Researcher**, Dept. of Astronomy, UC Berkeley **Jan 2017 - Aug 2019**  
*Adviser:* Dr. Imke de Pater  
**Visiting Scholar**, Keck Observatory **Summer 2017**  
*Adviser:* Dr. Carlos Alvarez  
**Research Assistant**, NASA Goddard Space Flight Center **Aug 2015 - July 2016**  
*Adviser:* Dr. Conor Nixon  
**Undergraduate Research Assistant**, Macalester College **Sep 2014 - May 2015**  
*Adviser:* Dr. John Cannon  
**NSF REU Research Student**, US Geological Survey/Northern Arizona U. **Summer 2014**  
*Adviser:* Dr. Colin Dundas  
**Visiting Research Student**, Université Libre de Bruxelles **Fall 2013**  
*Adviser:* Dr. Nicolas Chamel  
**Undergraduate Research Assistant**, Macalester College **Summer 2013**  
*Adviser:* Dr. John Cannon

### REFERREED JOURNAL ARTICLES

- \*Student Advised* <https://orcid.org/0000-0003-3799-9033>
24. \* Helfenbein, M., **Molter, E. M.**, de Pater, I., “Infrared Photometry of Neptune’s Small Moons with Keck”, in prep.
  23. Akins, A., Hofstadter, M., Butler, B. J., Friedson, A., **Molter, E. M.**, Parisi, M., de Pater, I., “Evidence of a Polar Cyclone on Uranus from VLA Observations”, GRL, in review
  22. de Pater, I., Lellouch, E., Stroebel, D. F., et al. incl. **Molter, E. M.**, “JWST Detects the Forbidden 1.707  $\mu\text{m}$  SO Emission Band Complex above Io’s Active Volcano Kanehekili Fluctus”, JGR:Planets, in review
  21. **Molter, E. M.**, de Pater, I., Moeckel, C., “Keck Near-Infrared Detections of Mab and Perdita”, Icarus Letters, in review

20. \* Chavez, E., de Pater, I., Redwing, E., **Molter, E. M.**, Roman, M. T., Zorzi, A., Alvarez, C., Campbell, R., de Kleer, K., Hueso, R., et al. “Evolution of Neptune at Near-Infrared Wavelengths from 1994 through 2022”, *Icarus*, in review
19. \* Chavez, E., Redwing, E., de Pater, I., Hueso, R., **Molter, E. M.**, Wong, M. H., Alvarez, C., Gates, E., de Kleer, K., et al., “Drift Rates of Major Neptunian Features between 2018 and 2021”, *Icarus*, in press (2023) <https://doi.org/10.1016/j.icarus.2023.115604>
18. de Pater, I., **Molter, E. M.**, Moeckel, C. M. “A Review of Radio Observations of the Giant Planets: Probing the Composition, Structure, and Dynamics of Their Deep Atmospheres”, *Remote Sensing*, 15, 5, 1313 (2023) <https://doi.org/10.3390/rs15051313>
17. Zhang, L., Risser, M., **Molter, E. M.**, Wehner, M. F., O’Brien, T. A., “Accounting for the spatial structure of weather systems in detected changes in precipitation extremes”, *Weather & Climate Extremes*, 100499 (2022) <https://doi.org/10.1016/j.wace.2022.100499>
16. **Molter, E. M.**, Collins, W. D., Risser, M. D., “Quantitative Precipitation Estimation of Extremes in CONUS with Radar Data”, *Geophysical Research Letters*, 48, 16 (2021) <https://doi.org/10.1029/2021GL094697>
15. Villanueva, G., Cordiner, M., Irwin, P., et al., incl. **Molter, E.**, “No evidence of phosphine in the atmosphere of Venus from independent analyses”, *Nature Astronomy* 5, 631-635 (2021) <https://doi.org/10.1038/s41550-021-01422-z>
14. \* Zorzi, A., **Molter, E. M.**, de Pater, I., Luszcz-Cook, S. H., Tollefson, J., Wong, M. H., “Evolution of Neptune’s Troposphere in 1994-2018 based on HST Observations”, *Astronomy & Astrophysics*, in review
13. Tollefson, J., de Pater, I., **Molter, E. M.**, Sault, R. J., Butler, B. J., Luszcz-Cook, S., DeBoer, D., “Neptune’s Spatial Brightness Temperature Variations from the VLA and ALMA”, *Planetary Science Journal* 2, 3 (2021) <https://doi.org/10.3847/PSJ/abf837>
12. **Molter, E. M.**, de Pater, I., Luszcz-Cook, S., Tollefson, J., Sault, R. J., Butler, B., de Boer, D., “Tropospheric Composition and Circulation of Uranus with ALMA and the VLA”, *Planetary Science Journal*, 2, 1 (2021) <https://doi.org/10.3847/PSJ/abc48a>
11. Nixon, C. A., Thelen, A. E., Cordiner, M. A., Kisiel, Z., Charnley, S. B., **Molter, E. M.**, Serigano, J., Irwin, P. G. J., Teanby, N., Kuan, Y., “Detection of Cyclopropenylidene on Titan with ALMA”, *Astronomical Journal*, 160, 5 (2020) <https://doi.org/10.3847/1538-3881/abb679>
10. **Molter, E. M.**, de Pater, I., Roman, M. T., Fletcher, L. N., “Thermal Emission from the Uranian Ring System”, *Astronomical Journal*, 158, 47 (2019) <https://doi.org/10.3847/1538-3881/ab258c>
9. de Kleer, K., de Pater, I., **Molter, E. M.**, Banks, E., Davies, A. G., Alvarez, C., Campbell, R., et al., “Io’s Volcanic Activity from Time Domain Adaptive Optics Observations: 2013-2018”, *Astronomical Journal*, 158, 29 (2019) <https://doi.org/10.3847/1538-3881/ab2380>
8. **Molter, E. M.**, de Pater, I., Luszcz-Cook, S., Hueso, R., Tollefson, J., Alvarez, C., Sánchez-Lavega, A., Wong, M. H., Hsu, A. I., Sromovsky, L. A., Fry, P. M., Delcroix, M., Campbell, R., de Kleer, K., Gates, E., Lynam, P. D., et al., “Analysis of Neptune’s 2017 Bright Equatorial Storm”, *Icarus*, 321, 324 (2019) <https://doi.org/10.1016/j.icarus.2018.11.018>
7. Thelen, A. E., Nixon, C. A., Chanover, N. J., Cordiner, M. A., **Molter, E. M.**, Teanby, N. A., Irwin, P. G. J., Serigano, J., Charnley, S. B., “Abundance Measurements of Titan’s Stratospheric HCN, HC<sub>3</sub>N, C<sub>3</sub>H<sub>4</sub>, and CH<sub>3</sub>CN from ALMA observations”, *Icarus*, 319, 417 (2019) <https://doi.org/10.1016/j.icarus.2018.09.023>
6. Cordiner, M. A., Nixon, C. A., Charnley, S. B., Teanby, N. A., **Molter, E. M.**, Kisiel, Z., Vuitton, V., “Interferometric Imaging of Titan’s HC<sub>3</sub>N, H<sup>13</sup>CCCN, and HCCC<sup>15</sup>N”, *Astrophysical Journal Letters*, 859, L15 (2018) <https://doi.org/10.3847/2041-8213/aac38d>

5. Thelen, A. E., Nixon, C. A., Chanover, N. J., **Molter, E. M.**, Cordiner, M. A., Achterberg, R. K., Serigano, J., Irwin, P. G. J., Teanby, N., Charnley, S. B., “Spatial variations in Titan’s atmospheric temperature: ALMA and Cassini comparisons from 2012 to 2015”, *Icarus*, 307, 380 (2018) <https://doi.org/10.1016/j.icarus.2017.10.042>
4. Lai, J. C.-Y., Cordiner, M. A., Nixon, C. A., Achterberg, R. K., **Molter, E. M.**, Teanby, N. A., Palmer, M. Y., Charnley, S. B., Lindberg, J. E., Kisiel, Z., Mumma, M. J., Irwin, P. G. J., “Mapping Vinyl Cyanide and Other Nitriles in Titans Atmosphere Using ALMA”, *Astronomical Journal*, 154, 206 (2017) <https://doi.org/10.3847/1538-3881/aa8eef>
3. **Molter, E. M.**, Nixon, C. A., Cordiner, M. A., Serigano, J., Irwin, P. G. J., Teanby, N. A., Charnley, S. B., Lindberg, J. E., “ALMA Observations of HCN and its Isotopologues on Titan”, *Astronomical Journal*, 152, 2 (2016) <https://doi.org/10.3847/0004-6256/152/2/42>
2. Warren, S. R., **Molter, E. M.**, Cannon, J. M., Bolatto, A. D., Adams, E. A. K., Bernstein-Cooper, E. Z., Giovanelli, R., Haynes, M. P., Herrera-Camus, R., Jameson, K., McQuinn, K. B. W., Rhode, K. L., Salzer, J. J., Skillman, E. D., “CARMA CO Observations of Three Extremely Metal-Poor, Star-Forming Galaxies”, *Astrophysical Journal*, 814, 30 (2015) <https://doi.org/10.1088/0004-637X/814/1/30>
1. Chamel, N., **Molter, E.**, Fantina, A. F., Arteaga, D. P., “Maximum strength of the magnetic field in the core of the most massive white dwarfs,” *Physical Review Letters D*, 90, 043002 (2014) <https://doi.org/10.1103/PhysRevD.90.043002>

**TELESCOPE  
TIME  
AWARDED**

**Atacama Large (sub-)Millimeter Array (ALMA)**

2. Primary Investigator, *Thermal Properties of the Uranian Rings*, 8.5 hours
1. Primary Investigator, *Opacity Variability in Uranus’s Troposphere*, 3.7 hours  
Funding awarded (\$17,500) via NRAO Student Observing Support Award

**James Webb Space Telescope (JWST)**

1. co-Investigator, *ERS observations of the Jovian System as a demonstration of JWST’s capabilities for Solar System science*, Instruments: Multiple; PIs: T. Fouchet and I. de Pater, 28.9 hours

**W. M. Keck Observatory**

3. co-Investigator, *The Twilight Zone: Cadenced Twilight Observations of Solar System Bodies*, long-term program. Instruments: NIRC2, Osiris; PIs: I. de Pater, K. de Kleer, A. Davies, 2018-present. >80 activations, 0.5 hours each
2. co-Investigator, *Spatial Distribution of H<sub>2</sub>S on Neptune and Uranus*, Instrument: OSIRIS; PI: I. de Pater, 1.0 nights
1. co-Investigator, *Uranus from Equinox to Mid-Spring: Tropospheric Temperatures, Seasonal Changes, and Emerging Rings*, Instrument: Subaru COMICS; PI: J. Sinclair, 1.0 nights

**Very Large Array (VLA)**

1. co-Investigator, *Seasonal Variations in the Microwave Emission of Uranus*, PI: Alex Akins, 18.0 hours

**Very Large Telescope (VLT)**

2. co-Investigator, *Uranus from Equinox to Mid-Spring: Temperature Structure, Photochemistry, Seasonal Changes, and Emerging Rings*, Instrument: VISIR; PI: M. Roman, 14.5 hours
1. co-Investigator, *Resolve Loki Patera on Jupiters Satellite Io with Matisse*, Instrument: MATISSE; PI: I. de Pater, 3 hours

**Paranal Observatory**

1. co-Investigator, *Preparatory observations for GTO program on Matisse of Io’s Loki Patera*, Instrument: NACO; PI: I. de Pater, XX activations, 0.5 hours each

**Lick Observatory**

1. Primary & co-Investigator, *Origin & Evolution of Storms, Clouds, and Hazes on Uranus and Neptune*, long-term program. Instrument: ShARCS; PIs: E. Molter, J. Tollefson, E. Redwing. >80 activations, 1 hour each

## OPEN-SOURCE SOFTWARE

I actively contribute to the open-source software ecosystem within planetary science:

- Contributed the Planetary Ring Node query tool to the **astropy**-coordinated **astroquery** package
- Developed the Twilight Zone observing tools and public-facing website at Keck Observatory
- Wrote the **nirc2\_reduce** package for processing Keck NIRC2 data, as published in e.g. Molter et al. 2019, de Kleer et al. 2021, Chavez et al. 2023a,b (in review)
- Contributed Uranus & Neptune cloud physics and MCMC support to the **radiobear** radiative transfer code, as published in e.g. Tollefson et al. 2021, Molter et al. 2021, de Pater et al. 2023
- Co-maintainer of the **sunbear** radiative transfer code, as published in e.g. Luszcz-Cook et al. 2016, Molter et al. 2019, Zorzi et al. 2023 (in review). First public release coming soon!
- **pyplanetary**

I recently adopted the **showyourwork!** workflow for open and reproducible scientific publications; my first paper using this package is available at this link.

## TEACHING, OUTREACH, & MENTORSHIP

<b>Mentor</b> , Berkeley Undergraduate Research Apprentice Program	Spring 2022 - Present
<b>Volunteer Organizer</b> , Berkeley Climate & Impacts Research Hub	Fall 2020 - Spring 2022
<b>Graduate Student Instructor</b> , UC Berkeley	
C162 Planetary Astrophysics	Fall 2018
C12 The Planets	Spring 2017
C10 Introduction to General Astronomy	Fall 2016
<b>Volunteer Panelist</b> , Branson School Science Symposium	2018, 2019
<b>Volunteer Instructor</b> , Splash @ Berkeley	2018
<b>Peer Mentor</b> , Berkeley Astronomy Dept.	Fall 2018 - Present
<b>Orientation Leader</b> , Macalester College Dept of Student Affairs	Fall 2012
<b>Program Staff (full-time)</b> , Camp Becket/Chimney Corners YMCA, Becket, MA	Summer 2012

## PROFESSIONAL DEVELOPMENT

<b>Astronomical Software Development Workshop</b> , Flatiron Institute, NY	May 2022
<b>Graduate Climate Conference (GCC)</b> , Virtual	October 2021
<b>Unlearning Racism in the Geosciences (URGE)</b> Berkeley Chapter, Virtual	Fall 2020
<b>JPL Center for Climate Sciences Summer School</b> , Virtual	August 2020
<b>Physics in Machine Learning Workshop</b> , Berkeley, California	May 2019
<b>Very Large Array (VLA) Synthesis Imaging Workshop</b> , Socorro, New Mexico	May 2018
<b>Very Large Array (VLA) Data Reduction Workshop</b> , Socorro, New Mexico	October 2017
<b>JWST Early Release Science Proposal Writing Workshop</b> , Leiden, Netherlands	May 2017
<b>Titan Aeronomy and Climate Workshop</b> , Reims, France	June 2016
<b>Combined Array for Research in Millimeter Astronomy (CARMA)</b> Summer School, Big Pine, CA	August 2014
<b>Undergraduate ALFALFA Team Workshop</b> , Arecibo, Puerto Rico	January 2014

## CONFERENCE PRESENTATIONS

15. “The Atmosphere and Rings of Uranus at 25 mas Resolution with ALMA”, AGU Fall Meeting, P23B-07 (2022)
14. “A Storm-Resolving Data Set for Analysis of Precipitation at its Native Scale, Diagnosis of Cloud-Resolving Models, and Development of Next-Generation Parameterizations”, AGU Fall Meeting, A45Q-2082 (2021)
13. “Quantitative Precipitation Estimation of Extremes over the Continental United States with Radar Data”, AMS Annual Meeting, 2A.1 (2021) [[click for video recording](#)]
12. **(Invited)** “Thermal Measurements of the Ring System of Uranus”, AGU Fall Meeting, P017-03 (2020)
11. “Quantitative Precipitation Estimation of Extremes over the Continental United States with Radar Data”, AGU Fall Meeting, A042-0014 (2020)

10. “Uranus’s Tropospheric Circulation and Composition with ALMA and the VLA”, EPSC/DPS Meeting 13, 726-1 (2019)
9. “Uranian Atmosphere and Rings Probed with ALMA Observations”, AAS/DPS Meeting, 50, 104.07 (2018)
8. “Mapping circulation and chemistry in Uranus’s deep atmosphere with radio observations”, Astrophysical Frontiers in the Next Decade and Beyond Meeting (2018)
7. “Discovery of a Bright Equatorial Storm on Neptune”, AGU Fall Meeting, P31D-2856 (2017)
6. “Isotopic Ratios in Nitrile Species on Titan using ALMA”, Titan Aeronomy & Climate Workshop, #37 (2016)
5. “Observations of HCN and its Isotopologues on Titan using ALMA”, AAS, 227, #141.19 (2016)
4. “Vertical Profiles and Isotopic Ratios in HCN and its Isotopologues from ALMA Observations of Titan”, AAS/DPS, 47, #310.15 (2015)
3. “Testing for the Influence of Insolation on Formation and Growth of Hollows on Mercury,” LPSC, 46, #1489 (2015)
2. “CO Observations of DDO 68: An Extreme Outlier on the Mass-Metallicity Relation”, AAS, 225, #248.18 (2015)
1. “The Low CO Luminosity of Three Extremely Metal-Poor Star-Forming Galaxies”, AAS, 223, #246.52 (2014)

## PUBLICITY

<b>Press Release</b> , UC Berkeley, “Berkeley Astronomers to Put New Space Telescope Through its Paces”	January 2022
<b>Interview</b> , Futurism, “Here’s What Uranus Scientists Think About Your Disgusting Jokes”	November 2021
<b>Press Release</b> , NASA, “NASA Scientists Discover ‘Weird’ Molecule in Titan’s Atmosphere”	October 2020
<b>Press Release</b> , UC Berkeley, “Astronomers see ‘warm’ glow of Uranus’s rings”	June 2019
<b>Nature Research Highlight</b> , “Epic storm roils a tranquil region of Neptune”	December 2018
<b>Press Release</b> , UC Berkeley/Keck Observatory, “New Storm Makes Surprise Appearance on Neptune”	August 2018

## SELECTED GRADUATE COURSEWORK

I took advantage of the rich academic program at UC Berkeley by enrolling in classes throughout my graduate career, going well beyond the coursework requirements:	
11. Effective Mentoring in Higher Education	Spring 2022
10. Python Computing for Data Science	Spring 2022
9. Unlearning Racism in the Geosciences (URGE)	Spring 2021
8. Global Circulation of Planetary Atmospheres	Fall 2020
7. Computational Fluid Dynamics	Fall 2020
6. Atmospheric Physics and Dynamics (audit)	Fall 2019
5. Astrophysical Fluid Dynamics	Spring 2018
4. Radiation and its Interactions with Climate	Fall 2017
3. Solar System Astrophysics	Fall 2017
2. Astrophysical Techniques	Spring 2017
1. Radiative Processes in Astronomy	Fall 2016