Michael P. Busch

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SUMMARY

Astrophysicist studying atomic and molecular gas in the Milky Way and the Local Group. My work established the 18 cm OH lines as a practical tracer of CO-dark molecular gas: I discovered a thick disk of diffuse molecular gas in the outer Galaxy, and published the first extragalactic detection of thermal OH emission. As PI or Co-I I have led 2,803 hours of competitively awarded time on the GBT, VLA, ALMA, NOEMA, and Parkes-Murriyang, across 20 refereed publications and three nationally competitive fellowships. My program is oriented toward faint-signal detection and large-survey analysis for the SKA and ngVLA era, and I collaborate extensively with domestic and international teams.

EMPLOYMENT HISTORY

Jansky Postdoctoral Fellow 2025–Present
National Radio Astronomy Observatory

- Independent postdoctoral researcher leading ISM spectroscopy programs with the GBT, VLA, ALMA, and other facilities.

NSF Astronomy and Astrophysics Postdoctoral Fellow 2022–2025
University of California, San Diego

- Independent research postdoc in the Department of Astrophysics & Astronomy sponsored and mentored by Dr. Karin Sandstrom. Leading research projects focused on the physics of the interstellar medium using molecular spectroscopy with various telescopes with a focus on radio, mm and far-IR wavelengths.

NSF Graduate Research Fellow 2016–2022
The Johns Hopkins University

- Five years of NSF GRFP award which provided three years of independent funding for graduate school research. Additionally two years of competitive funding was acquired from the Director's Discretionary Fund from Space Telescope Science Institute. Research focused on the interstellar medium, tracing diffuse molecular gas, radio astronomy methods and molecular spectroscopy.

NASA Space Grant Research Intern 2013–2016
Arizona State University

- Research intern funded by the NASA Space Grant Consortium in the lab of Judd D. Bowman. Carried out research in low frequency cosmology with various radio telescopes.

EDUCATION

Doctor of Philosophy (Ph.D), Physics 2016–2022
The Johns Hopkins University
Thesis: *On the Dark Molecular Gas as Revealed by 18 cm OH Emission*
Research Advisors: Ronald J. Allen (Astronomer Emeritus, Space Telescope Science Institute (STScI)), Joshua E. G. Peek (Associate Astronomer, STScI. Associate Research Scientist, JHU)

Master of Arts (M.A.), Physics 2016–2018
The Johns Hopkins University
Project: *The Cepheid Distance to M31 to Sub-2% Using Hubble Space Telescope Photometry*
Research Advisor: Adam G. Riess (Nobel Laureate, Bloomberg Distinguished Professor, JHU. Distinguished Astronomer, STScI)

Bachelor (BS) Physics, Bachelor (BS) Astrophysics 2012–2016
Arizona State University
Honor's Thesis: *Characterizing Extragalactic Radio Foregrounds for the Murchison Widefield Array using the Jansky Very Large Array*
Research Advisor: Judd D. Bowman (Professor, School of Earth and Space Exploration, ASU)

REFEREED PUBLICATIONS

20. Cosima Eibensteiner, Adam K. Leroy, Jiayi Sun, Erik Rosolowsky, Eric W. Koch, Nickolas Pingel, Chang-Goo Kim, Laura B. Chomiuk, Ryan Chown, Alberto D. Bolatto, **Michael P. Busch** and 13 others, "A Multiwavelength Inventory for the Local Group L-band Survey. I. Atlas and Radial Profiles of Local Group Galaxies", *ApJS* **286**, 53 (2026).

19. Daniel R. Rybarczyk, **Michael P. Busch**, J. R. Dawson, Min-Yeoung Lee, Gan Luo, "CO-dark molecular gas traced by HCO+ in the diffuse interstellar medium", *ApJ* **1005**, 125 (2026).

18. W.-J. Kim, A. M. Jacob, D. A. Neufeld, P. Schilke, H. Wiesemeyer, M. Gerin, M. G. Wolfire, V. Ossenkopf-Okada, V. Valdivia, E. Falgarone, D. C. Lis, S. Bialy, M. R. Rugel, Á. Sánchez-Monge, **M. Busch** and 5 others, "HyGAL: Characterizing the Galactic ISM with Observations of Hydrides and Other Small Molecules. III. The Absorption Lines of [O I], CH, and OH", *A&A* **710**, A301 (2026).

17. Daniel R. Rybarczyk, Eric W. Koch, Fabian Caballero Vargas, Snežana Stanimirović, Nickolas M. Pingel, Julianne J. Dalcanton, Adam K. Leroy, Erik W. Rosolowsky, **Michael P. Busch**, Chang-Goo Kim, Adam Smercina, Elizabeth Tarantino, Vicente Villanueva, Alberto D. Bolatto, and Thomas G. Williams, "Revisiting Ram Pressure Stripping in Wolf–Lundmark–Melotte: No Evidence for Stripped H I with Local Group L-Band Survey", *AJ* **172**, 2 (2026).

16. Enrico M. Di Teodoro, Mark Heyer, Mark R. Krumholz, Lucia Armillotta, Felix J. Lockman, Andrea Afruni, **Michael P. Busch**, Naomi M. McClure-Griffiths, Karlie A. Noon, Nicolas Peschken and Qingzheng Yu, "A survey of molecular clouds in the Galactic center's outflow", *A&A* **706**, A330 (2026).

15. Ioana A. Stelea, Snežana Stanimirović, Nickolas M. Pingel, Hongxing Chen, Eric W. Koch, Adam K. Leroy, Erik Rosolowsky, Chang-Goo Kim, Alberto D. Bolatto, Julianne J. Dalcanton,

Michael P. Busch and 12 others, "The Local Group L-band Survey: Probing Cold Atomic Gas in IC 10 with Neutral Hydrogen Absorption", *ApJ* **997**, 328 (2026).

14. Eric F. Bell, Benjamin Harmsen, Matthew Cosby, Paul A. Price, Sarah Pearson, Antonela Monachesi, Roelof S. de Jong, Richard D' Souza, Katya Gozman, Jacob Nibauer, **Michael P. Busch**, Jeremy Bailin, Benne W. Holwerda, In Sung Jang, and Adam Smercina, "The Low-mass and Structured Stellar Halo of M83 Argues Against a Merger Origin for Its Starburst and Extended Neutral Hydrogen Disk", *ApJ* **997**, 153 (2026).

13. Eric W. Koch, Adam K. Leroy, Erik W. Rosolowsky, Laura Chomiuk, Julianne J. Dalcanton, Nickolas M. Pingel, Sumit K. Sarbadhicary, Snežana Stanimirović, Fabian Walter, Haylee N. Archer, Alberto D. Bolatto, **Michael P. Busch**, Hongxing Chen, Ryan Chown, Harrisen Corbould, Serena A. Cronin, Jeremy Darling, Thomas Do, Jennifer Donovan Meyer, Cosima Eibensteiner and 30 others, "The Karl G. Jansky Very Large Array Local Group L-Band Survey (LGLBS)", *ApJS* **279**, 35 (2025).

12. Rugel, M. R., Beuther, H., Soler, J. D. , Goldsmith, P., Anderson, L., Hafner, A., Dawson, J. R., Wang, Y., Bihr, S., Wiesemeyer, H., Güsten, R., Lee, M.-Y., Riquelme, D., Jacob, A. M., Kim, W.-J., **Busch, M.**, Khan, S., Brunthaler, A., "Faint absorption of the ground state hyperfine-splitting transitions of hydroxyl at 18 cm in the Galactic disk", *A&A* **700**, A171 (2025).

11. Renzhi Su, Tao An, Stephen J. Curran, **Michael P. Busch**, Minfeng Gu, and Di Li, "Constraints on the Fractional Changes of the Fundamental Constants at a Look-back Time of 2.5 Myr", *ApJL* **981**, L25 (2025).

10. Nickolas M Pingel, Hongxing Chen, Snežana Stanimirović, Eric W Koch, Adam K Leroy, Erik Rosolowsky, Chang-Goo Kim, Julianne J Dalcanton, Fabian Walter, **Michael P. Busch**, Ryan Chown, Jennifer Donovan Meyer, Cosima Eibensteiner and 5 others, "The Local Group L-band Survey: The First Measurements of Localized Cold Neutral Medium Properties in the Low-metallicity Dwarf Galaxy NGC 6822", *ApJ* **974**, 93 (2024).

9. Hiep Nguyen, NM McClure-Griffiths, James Dempsey, John M Dickey, Min-Young Lee, Callum Lynn, Claire E Murray, Snežana Stanimirović, **Michael P. Busch**, Susan E Clark, JR Dawson and 13 others, "Local HI absorption towards the magellanic cloud foreground using ASKAP", *MNRAS* **534**, 3478 (2024).

8. **Busch, Michael P.**, "First Extragalactic Detection of Thermal Hydroxyl (OH) 18 cm Emission in M31 Reveals Abundant CO-faint Molecular Gas", *ApJ* **967**, 148 (2024).

7. A. M. Jacob, D. A. Neufeld, P. Schilke, H. Wiesemeyer, W. Kim, S. Bialy, **M. Busch** and 19 others, "HyGAL: Characterizing the Galactic Interstellar Medium with Observations of Hydrides and Other Small Molecules. I. Survey Description and a First Look Toward W3(OH), W3 IRS5, and NGC 7538 IRS1", *ApJ* **930**, 141 (2022).

6. Li, Siyang; Riess, Adam G.; **Busch Michael P.**; Casertano, Stefano; Macri, Lucas M., Yuan, Wenlong., "A sub-2% Distance to M31 from Photometrically Homogeneous Near-Infrared Cepheid Period-Luminosity Relations Measured with the Hubble Space Telescope", *ApJ* **920**, 84 (2021).

5. **Busch M.P.**, Engelke P.D., Allen R.J., Hogg D.E., "Observational Evidence for a Thick Disk of Dark Molecular Gas in the Outer Galaxy", *ApJ* **914**, 72 (2021).

4. Engelke P, Allen R, **Busch M.P.**, "Star-forming versus Quiescent Regions in the Galaxy: A Case Study of ISM Properties Based on 18 cm OH and 12CO(1-0) Observations", *ApJ* **901**, 50 (2020).

3. **Busch M.P.**, Allen R.J., Engelke P.D., Hogg D.E., Neufeld D.A, Wolfire M.G., "The Structure of Dark Molecular Gas in the Galaxy – II. Physical State of CO-Dark Gas in the Perseus Arm", *ApJ* **883**, 158 (2019).

2. Daniel C, Jacobs, Jacob Burba, Judd D. Bowman, Abraham N. Neben, Benjamin Stinnett, Lauren Turner, Kali Johnson, **Micheal P. Busch**, and 5 others., "First Demonstration of ECHO: an External Calibrator for Hydrogen Observatories", *PASP* **129**, 973 (2017).

1. A.P. Beardsley, B.J. Hazelton, I.S. Sullivan, P. Carroll, N. Barry, M. Rahimi, B. Pindow, C.M. Trott, J. Line, Daniel C. Jacobs, M.F. Morales, J.C. Pober, G. Bernardi, Judd D. Bowman, **Busch M.P.**, and 41 others., "First Season MWA EoR Power Spectrum Results at Redshift 7", *ApJ* **833**, 102 (2016).

WHITE PAPERS AND BOOK CHAPTERS

3. A. Karska, J. R. Dawson, A. M. Jacob, T. V. Wenger, J. S. Urquhart, D. Colombo, L. D. Anderson, V. S. Veena, M. Rugel, M. A. Thompson, P. D. Klaassen, H. Beuther, **M. P. Busch**, A. Traficante, and G. Sabatini, "Spectroscopic Surveys with the SKA Probing the Ionized and Molecular Milky Way", *Advancing Astrophysics with the SKA II (AASKA II)* **arXiv**, 2606.25901 (2026).

2. K. L. Emig, F. Combes, M. Aravena, R. Beswick, **M. Busch**, V. Casasola, M. Cordiner, S. Etoka, B. Liu, R. Loomis, N. van der Marel, S. Martín, B. McGuire, I. de Pater, and H. Roberts, "New and Future Discoveries Observing Molecular and Radio Recombination Lines", *Proceedings of the International Astronomical Union (IAU GA 2024, Focus Meeting 5)* **20**, A32, 181–189 (2024).

1. Anish Roshi, D., Aponte, N., Araya, E., Arce, H., Baker, L. A., Baan, W., Becker, T. M., Breakall, J. K., Brown, R. G., Brum, C. G. M., **Busch, M.P.**, Campbell, D. B., Cohen, T., Cordova, F., Deneva, J. S., Devogele, M., Dolch, T., Fernandez-Rodriguez, F. O., Ghosh, T., Goldsmith, P. F., and 26 others, "The Future Of The Arecibo Observatory: The Next Generation Arecibo Telescope", *Arecibo Observatory White Paper* **arXiv eprint**, 2103.01367 (2021).

SUBMITTED AND IN PREPARATION

Summary: Five manuscripts in the pipeline, **four as first or sole author**, spanning OH excitation calibration, extragalactic OH surveys, and molecular gas in the Galactic nuclear wind.

S5. **Busch, M. P.**, Neufeld, D. A., Rugel, M. R., Jacob, A. M., Kim, W.-J., Schilke, P., "HyGAL: Characterizing the Galactic ISM with Observations of Hydrides and Other Small Molecules. IV. The Excitation of Interstellar OH Revisited", *to be submitted to ApJ* (2026).
First empirical calibration of the OH 18 cm excitation temperatures against far-infrared OH transitions, using SOFIA HyGAL and VLA data — resolving the dominant systematic in all OH-based column density measurements.

S4. **Busch, M. P.**, "A Green Bank Telescope Search for the Diffuse Molecular Gas Disk in 18 cm OH Absorption Against Outer-Galaxy H II Regions", *in preparation* (2026).
Sole author. Direct measurement of the OH 18 cm excitation temperature by catching the emission-to-absorption transition against a rising continuum background ($T_{\rm ex}(1667) = 6.44 \pm 0.13$ K), with no chemical or excitation model assumed.

S3. **Busch, M. P.**, "Thermal OH 18 cm Emission across the Northern Molecular Ring of Andromeda: CO-faint Molecular Gas Is Ubiquitous", *in preparation* (2026).
Sole author. First multi-position 18 cm OH survey of an external galaxy: 16 GBT pointings (140 hr), OH detected toward 13, establishing that CO-faint molecular gas is pervasive across M31's molecular ring.

S2. **Busch, M. P.**, Di Teodoro, E. M., Lockman, F. J., McClure-Griffiths, N. M., Noon, K. A., Krishnarao, D., Armillotta, L., "A Deep Search for 18 cm OH Emission from Molecular Clouds in the Milky Way's Nuclear Wind: Detection of OH in MW-C2", *in preparation* (2026).
First OH detection in a nuclear-wind cloud, 1.8 kpc into the Galactic outflow.

S1. Liu, M., Li, D., Dawson, J. R., Weisberg, J. M., **Busch, M. P.**, Rybarczyk, D. R., Hobbs, G., Quan, D., Tsai, C.-W., Bisbas, T., "First High-Sensitivity OH Measurements toward a Pulsar (PSR J1644−4559)", *submitted* (2026).

OBSERVING PROPOSALS

Summary: Awarded **2803 hours** of competitive observing time as PI/Co-I since 2019 across GBT, VLA, ALMA, NOEMA, and Murriyang-Parkes, demonstrating consistent success leading large observational programs on faint OH surveys and CO-dark molecular gas tracers.

- **ALMA, 2026.1.01314.S, PI:** *An Observational Test of the CO-Dark H2 Disk in the Outer Galaxy with Extremely Sensitive ALMA HCO+ Absorption* 3.5 hours awarded
- ALMA, 2026.1.01760.S, Co-PI: *Tracing the HI-to-H2 Transition in the Large Magellanic Cloud with Cold Atomic Gas and CO* 19.3 hours awarded
- ALMA, 2026.1.01175.S, Co-PI: *Measuring CO-Dark Molecular Gas in N66 with ALMA and JWST* 43.8 hours awarded
- ALMA, 2026.1.01107.S, Co-PI: *Resolving Dense Molecular Cores in M33 and Linking Them to Their Cold Atomic Envelopes* 19.1 hours awarded
- **GBT, GBT26B-360, PI:** *A GBT Survey of M33's Molecular Gas in OH* 168 hours awarded
- GBT, GBT26B-301, CO-I: *Ionized gas (H, He, RRLs) and cool "dark" gas (CRRLs, OH) around DR21 with UWBR* 35 hours awarded
- **GBT, GBT26B-263, PI:** *Structure of Diffuse Molecular Gas in OH and HCO^+: Extending the Sample* 96 hours awarded
- **GBT, GBT26A-578, PI:** *Extending the GBT M31 Molecular Ring Survey in OH* 132 hours awarded
- VLA, VLA26A-525, Co-I: *Deep OH absorption observations in the Outer Galaxy* 350 hours awarded.

- **GBT, GBT26A-482, PI:** *Tracing Dark Molecular Gas in the Eos Molecular Cloud with 18 cm OH*, 100 hours awarded.
- VLA, VLA26A-411, CO-I: *The structure and physical properties of CO-dark diffuse molecular gas*, 18.8 hours awarded.
- **Murriyang, P1385, PI:** *CryoPAF Mapping of OH in a High-Latitude Cloud*, 100 hours awarded.
- NOEMA, W25AZ, CO-I: *The structure and chemistry of diffuse molecular gas: a multi-tracer program*, 15 hours awarded.
- **GBT, GBT25A-129, PI:** *A Survey for OH in the Northern Molecular Ring of M31*, 176 hours awarded.
- **GBT, GBT24B-320, PI:** *A Follow-up GBT Survey for OH in the Milky Way's Nuclear Wind*, 121 hours awarded.
- NOEMA, W24BG, CO-I: *Probing the structure of the diffuse molecular ISM near the HI-to-H2 transition*, 5.5 hours awarded.
- **GBT, GBT24A-144, PI:** *Probing the structure of the diffuse molecular ISM–mixed or clumped?*, 216 hours awarded.
- VLA, VLA24A-088, CO-I: *The properties of CO-dark molecular gas in the diffuse interstellar medium*, 7.2 hours awarded.
- **GBT, GBT23B-203, PI:** *Detangling the 3D Multi-phase Structure of the Perseus Cloud with 18cm OH*, 92.5 hours awarded.
- NOEMA, W23AC, CO-I: *CO-dark H2 traced HCO^+ absorption and OH emission: implications for the structure of diffuse molecular gas*, 12 hours awarded.
- **GBT, GBT23A-132, PI:** *Searching for OH in the Nuclear Wind in the Milky Way*, 20 hours awarded.
- **GBT, GBT22A-434, PI:** *Special Call: Is the Broad 18cm OH Emission 'Disk' in Concordance with Galactic Structure?*, 300 hours awarded.
- **Murriyang, P1130, PI:** *A Parkes Ultra-Deep Search for OH and CH in the Diffuse ISM of the Magellanic System*, 100 hours awarded.
- **GBT, GBT21A-088, PI:** *A GBT Search for the Diffuse Molecular Gas Disk in Absorption*, 177 hours awarded.
- **GBT, GBT20B-044, PI:** *Turbulent Motions, Mass Content and Distribution of Dark H2 in the Outer Galaxy*, 135 hours awarded.
- **GBT, GBT20B-014, PI:** *A GBT Search for an Extended Disk of OH Emission in M33*, 70 hours awarded.
- **GBT, GBT20A-573, PI:** *An Exploratory Study: OH Masers from the Smith Cloud Ridge?*, 15.75 hours awarded.

- **GBT, GBT20A-572, PI:** *A GBT Search for High Latitude "CO-Dark" Molecular Gas*, 85 hours awarded.
- GBT, GBT20A-556, Co-I: *A GBT Search for an Extended OH Molecular Disk in M31*, 70 hours awarded.
- GBT, GBT19A-484, Co-I: *Reconnaissance of an Extended OH Emission Feature in the Outer Galaxy*. 100 hours awarded.

TALKS AND CONFERENCES

37. OH as a Tracer of CO-Dark Gas in the Interstellar Medium Near and Far, Madison, Wisconsin, 4/2026 Invited Talk: *OH as a "CO-Dark" Gas Tracer Near and Far* Recording
36. NRAO/UVA Astronomy Colloquium, Charlottesville, Virginia, 3/2026 Invited Talk: *OH as a "CO-Dark" Gas Tracer Near and Far* Recording
35. AAS 247th Meeting, Phoenix, Arizona, 1/2026 Contributed Talk: *A GBT Survey of the Northern Molecular Ring in Andromeda*
34. Macquarie University Astro seminar, Sydney, Australia, 11/2025 Invited Talk: *OH as a "CO-Dark" Gas Tracer Near and Far*
33. CSIRO Space & Astronomy Colloquium, Marsfield, Australia, 11/2025 Invited Talk: *OH as a "CO-Dark" Gas Tracer Near and Far*
32. Interstellar Institute 7, Paris, France, 7/2025 Participant, discussion leader
31. Contents of the Fermi Bubbles and Related Topics, Green Bank, West Virginia, 4/2025 Scientific Organizing Committee, Contributed Poster: *A GBT 18cm OH Survey of Cold Molecular Gas in the Nuclear Wind*
30. GBT Surveys of the 21cm Sky, Green Bank, West Virginia, 3/2025 Scientific Organizing Committee, Contributed Talk: *Phased Array Feeds and Mapping Dark Molecular Gas with OH*
29. AAS 245 Meeting, National Harbor, Maryland, 1/2025 Contributed Talk: *First Extragalactic Detection of Thermal Hydroxyl (OH) 18cm Emission in M31 Reveals Abundant CO-faint Molecular Gas*
28. The San Diego-Ensenada Astronomical Society (ESDAS) Meeting, Instituto de Astronomia, Universidad Nacional Autonoma de Mexico, 9/2024 Contributed Talk: *Shedding Light on the Dark Molecular Gas: OH as a Tracer for H2 in the Interstellar Medium*
27. Heritage of SOFIA, University of Stuttgart, Stuttgart, Germany, 4/2024 Contributed Poster: *HyGAL III: An IR Calibration of 18cm OH Excitation from the HyGAL SOFIA Legacy Program*
26. Green Bank Community Zoom, Science Seminar, 1/2024, Invited Talk: *Detection of faint normal 18cm OH emission from CO-Faint Dark Molecular Gas in M31* Recording

25. CMB-S4 Summer Collaboration Meeting, SLAC National Lab, Palo Alto, 8/2023 Galactic Science Plenary Co-Chair, Invited Talk: *Dark Molecular Gas And Other Synergies between Dust and Gas Tracers for CMB Galactic Science*

24. Interstellar Institute 6, Paris, France, 7/2023 Contributed Talk: *Shedding Light on the Dark Molecular Gas: OH as a Tracer for Dark H_2 in the Galaxy and Beyond*

23. Olympian Symposium on Star Formation, Paralia, Greece, 6/2023 Contributed Poster: *Shedding Light on the Dark Molecular Gas*

22. Harvard SMA Science Seminar, Cambridge, Massachusetts, 4/2023 Invited Talk: *Shedding Light on the Dark Molecular Gas: OH as a Tracer for Dark H_2 in the Galaxy and Beyond*

21. Texas A&M Mitchell Institute Seminar, College Station, Texas, 4/2023 Invited Talk: *Shedding Light on the Dark Molecular Gas: OH as a Tracer for Dark H_2 in the Galaxy*

20. UCSD/SDSU Astronomy & Astrophysics Colloquium, San Diego, California, 3/2023 Invited Talk: *Shedding Light on the Dark Molecular Gas: OH as a Tracer for Dark H_2 in the Galaxy*

19. AAS 241 Meeting, Seattle, Washington, 1/2023 Participant

18. NSF AAPF Annual Symposium, Seattle, Washington, 1/2023 Invited Talk: *Revealing the Galactic Dark H_2*

17. Interstellar Institute 5: With Two Eyes, Paris, France, 7/2022

16. Our Galactic Ecosystem: Opportunities and Diagnostics in the Infrared and Beyond, Lake Arrowhead, California, 2/2022 Contributed Poster: *Revealing the Galactic Dark H_2*

15. Green Bank Community Zoom, Science Seminar, Zoom Virtual Talk, Green Bank, West Virginia, 8/2021 Invited Talk: *Revealing the Galactic Dark H_2 with Faint OH Emission* Recording

14. Interstellar Institute 4: "The Grand Cascade", Orsay, Île-de-France, France, 7/2021 Invited Talk: *Revealing the Galactic Dark H_2 with Faint OH Emission*

13. CSIRO Space & Astronomy Colloquium, Virtual Talk, Australia, 6/2021 Invited Talk: *Revealing the Galactic Dark H_2 with Faint OH Emission*

12. AAS 235th Meeting, Honolulu, Hawaii, USA, 6/2021 Contributed talk: *The Physical State of "CO-Dark" Gas in the Perseus Arm* Contributed poster: *OH as a tracer for the Diffuse Molecular Hydrogen*

11. Celebrating 40 years of Xander Tielens' Contributions to Science: The Physics and Chemistry of the Interstellar Medium, Avignon, Provence, France, 9/2019 Contributed talk: *The Physical State of "CO-Dark" Gas in the Perseus Arm* Contributed poster: *OH as a tracer for the Diffuse Molecular Hydrogen*

10. OH What a Lovely Molecule: Hydroxyl as a Probe of the Dark ISM, Sutton Forest, Southern Highlands, New South Wales, Australia, 4/2018 Contributed talk: *Tracing Dark Molecular Gas with OH 18-cm Emission using the Green Bank Telescope*

9. Johns Hopkins Astrophysics Wine and Cheese Seminar, Baltimore, MD, 3/2018 Contributed talk: *Tracing Dark Molecular Gas with OH 18-cm Emission using the Green Bank Telescope*

8. AstroconDC 2017, a Neighborhood Astronomy Conference, Washington DC, 8/2017 Contributed talk: *Probing the Structure of Dark Molecular Gas in the Perseus Arm with the GBT One-Square-Degree Survey*

7. NASA Undergraduate Research Symposium, Tucson, AZ, 4/2016 Contributed talk: *Foreground Characterization for the Murchison Widefield Array*

6. 227th AAS Meeting, Kissimmee, FL, 1/2016 Poster: *Foreground Characterization for the Murchison Widefield Array Using the Jansky Very Large Array*

5. Annual APS Four Corners Section, Tempe, AZ, 8/2015 Contributed talk: *Characterizing the Stellar Halo of M83*

4. Local Group Astrostatistics Conference, Ann Arbor, MI, 6/2015 Attended

3. NASA Undergraduate Research Symposium, Tempe, AZ, 4/2014 Contributed talk: *The External Calibrator for Hydrogen Observatories (ECHO)*

2. Vanderbilt EDGE Visiting Scholars Research Presentations, Nashville, TN, 10/2014 Contributed talk: *Investigating the Epoch of Reionization using the MWA*

1. NASA Undergraduate Research Symposium, Tucson, AZ, 4/2014 Contributed talk: *Epoch of Reionization: Creating a Data Quality Metric for the MWA*

RESEARCH EXPERIENCE

- Academic Years 2025-Present: Independent Research as a Jansky Fellow at the NRAO continuing observations with the 100m Green Bank Telescope, SOFIA, JWST, VLA, MeerKAT, NOEMA, ALMA. Member of international collaborations GASKAP, LGLBS, SKA Molecular Line Science Working Group, and HyGal SOFIA Legacy Survey. Expanding network of radio astronomers interested in diffuse molecular gas structure.

- Academic Years 2022-2025: Independent Research as an NSF AAPF at UCSD continuing observations with the 100m Green Bank Telescope, SOFIA, JWST, VLA. Member of international collaborations GASKAP, LGLBS, and HyGal SOFIA Legacy Survey.

- Academic Years 2016-2021: Conducting research with Ron Allen and Josh Peek using the 100m Green Bank Telescope and 20m Green Bank Observatory Telescope to directly observe and map the structure and kinematics of dark molecular gas using the OH molecule and comparing it to 3D dust, HI and CO observations.

- Academic Years 2016-2018: Member of Adam Riess' group at JHU, determining local distances with Cepheids to higher precision using the Hubble Space Telescope.

- Academic Years 2012-2016: Member of the Low-Frequency Cosmology Lab. Helped lead a team of undergraduates build the External Calibrator for Hydrogen Observatories (ECHO, see publications). Also aided in the construction of the Murchison Widefield Array's data pipeline (see publications). Senior thesis in the characterization of radio foregrounds for hydrogen observatories using the Very Large Array.

- Summer of 2016: NSF International Research Experience for Undergraduates in Bochum, Germany and Hamburg, Germany. Advisors: Prof. Evan Scannapieco (ASU), Prof. Ralf Jurgen-Dettmar (Ruhr-Bochum), Prof. Marcus Bruggen (U. Hamburg). Project: Measuring the Galactic Magnetic Fields of M108 and M83.
- Summer of 2015: NSF REU Student at University of Michigan with Prof. Eric Bell. Project: Characterizing the Stellar Halo of M83 and Searching for Satellite Galaxies and Tidal Streams with Subaru.

SERVICE

- **Invited Referee for**:
  The Astrophysical Journal
  Journal of Astronomical Telescopes, Instruments, and Systems
  Nature
- Hubble Space Telescope Cycle 33, **Telescope Allocation Committee** (2025)
- Advanced Research Grants (ARG) Program – Puerto Rico Science, Technology & Research Trust, **Grant Reviewer** (2025)
- UCSD STARTAstro, **Research Mentor** (Summer 2024, Summer 2025).
- OH What a Lovely Molecule, Online Conference, **Scientific Organizing Committee** (2025).
- Contents of the Fermi Bubbles and Related Topics, Conference at Green Bank Observatory, **Scientific Organizing Committee** (2025).
- GBT Surveys of the 21cm Sky, Conference at Green Bank Observatory, **Scientific Organizing Committee** (2025).
- Advanced L-band Phased Array Camera for Astronomy (ALPACA), Green Bank Telescope **Science Advisory Committee** (2023-2025).
- Five Hundred Meter Aperture Telescope (FAST), **Time Allocation Committee** (Spring 2023, Spring 2024).
- NRAO Tuna Talk Seminar Series, **Co-organizer** (2025-present).
- UCSD Department of Astronomy & Astrophysics, **Journal Club and Colloquium Committee** (2023-2025).
- Johns Hopkins Physics and Astronomy Graduate Students (PAGS), **President** (Elected, 2017-2019).
- AstroConDC, **Scientific Organizing Committee**, (2017).
- **Graduate Journal Club Organizer and host**: A Johns Hopkins Graduate Student Journal Club for younger graduate students to practice presenting their research and answering questions. (2017-2019)
- Johns Hopkins University Physics and Astronomy **Outreach Coordinator** to K-12 Schools in the Baltimore Area. (2016-2017)

- Arizona State University **Low-Frequency Cosmology Lab Outreach Coordinator** Facilitate Starlab Planetariums shows to school children and the Arizona Navajo Reservation with Dr. Karen Knierman (2013-2016)

ACTIVITIES AND WORKSHOPS

- LSSTc Data Science Fellowship: Member of Cohort 3 of Graduate Students, a two-year training program designed to teach astronomy students essential skills for dealing with big data from the LSST, learning a wide range of skills from building code, statistics, machine learning, image processing, visualization and communication.
- Apache Point Observatory ARC 3m Telescope Training: three days of observational projects with the objective of teaching observational essentials and granted certification for remote observing with APO. Projects: Exoplanet transits, nebulae, galaxies, spectra of AGN.
- Green Bank Telescope 100m Telescope Training, GBO Single Dish Summer School: a week-long summer school on the operations of the GBT telescope. Included three nights of observing from the control room. Projects included spectral line observations of molecular clouds and pulsar searches. Remote observer certified.

AWARDS, SCHOLARSHIPS, FELLOWSHIPS

Summary: Recipient of $\sim$ \$811k in competitive awards since 2012, including two of the field's premier early-career fellowships (NRAO Jansky Fellowship; NSF AAPF) as well as multiple national and institutional honors.

- 2025-Present Jansky Postdoctoral Fellow
- 2022-2025 National Science Foundation Astronomy and Astrophysics Postdoctoral Fellow
- 2019-2021 LSSTC Data Science Fellow
- 2016-2021 National Science Foundation Graduate Research Fellow
- 2014-2015 ASU Community Builder Award
- 2013-2015 ASU Astrophysics Undergraduate Student of the Year (2x)
- 2015-2016 Inaugural Origins Project Undergraduate Research Scholarship
- 2012-2016 NASA Undergraduate Space Grant Fellowship Recipient (3x)
- 2012-2016 ASU High Honors Regents Endorsement, President Barack Obama Scholar
- 2012 Dorrance Scholarship Honorable Mention

TEACHING EXPERIENCE

My teaching approach emphasizes active learning, inclusive instruction, and the development of practical scientific skills. In the classroom, I use group-based problem solving, guided inquiry, and structured opportunities for students to ask questions and collaborate with peers. In office hours, I encourage students to engage with one another's questions to build confidence, communication, and community. I am certified by The Carpentries to teach data-intensive computing through live-coding Python workshops, which I have taught at UCSD to support undergraduate transfer students in developing research-ready computational skills. At Johns Hopkins University, I served as a teaching assistant for multiple undergraduate physics courses, leading lab sections and recitation sessions.

- **STARTastro – Undergraduate Transfer Python Workshop**
  UCSD (Summer 2024, Summer 2025)
  Role: Instructor for a 2-week live-coding Python workshop series
- **Transfer Student Research Workshop Series**
  UCSD (Fall 2023, Fall 2024)
  Role: Instructor for 1-day scientific Python workshop
- **Physics I for Engineers (AS.171.101)**
  The Johns Hopkins University, Fall 2016
  Role: Teaching Assistant (led recitation sections, grading and office hours)
- **Physics I Lab: Mechanics (AS.173.111)**
  The Johns Hopkins University, Fall 2016
  Role: Teaching Assistant (led lab sections, graded lab reports)
- **Light and Optics (AS.171.411)**
  The Johns Hopkins University, Spring 2017
  Role: Teaching Assistant (recitations, demonstrations, grading and office hours)
- **Physics II Lab: Electricity & Magnetism (AS.173.112)**
  The Johns Hopkins University, Spring 2017
  Role: Teaching Assistant (led lab sections, graded lab reports)

STUDENT MENTORSHIP

My mentoring philosophy centers on helping students take intellectual ownership of their research at a pace aligned with their interests, strengths, and long-term goals. I work with each student to define milestones, develop technical skills, and build confidence in independent research. I prioritize providing opportunities for networking, conference participation, and collaboration, and I strive to create an inclusive, supportive environment grounded in curiosity about the underlying physics.

- **Cayden Tirak** – (NRAO REU Summer Student, Elon University, Summer 2026)
  Project: OH Masers in IC10 in the Local Group L-Band Survey
- **Muntaha Dhami** – (SDSU Astrophysics Undergraduate, Summer 2025)
  Project: A 18cm GBT OH survey of the Perseus Molecular Cloud

- **Justin Mascari**, (UCSD Astrophysics Undergraduate, 2024-present)
  Project: CO-Dark Molecular Gas content in M33
  Co-advising with Dr. Karin Sandstrom (UCSD)

- **Leo Intriligator** – (UC Berkeley Chemistry Undergraduate, 2024-2024)
  Project: Upper Limits on the OH molecule in the Outer Disk of M33

- **Seven Dunn** – (UCSD Astrophysics Undergraduate, 2023-2025)
  Project: CO-Dark Molecular Gas Content of High-Latitude Clouds

- **Julianne Tamayo** – (UCSD Astrophysics Undergraduate, 2023-2024)
  Project: Parkes-Murriyang OH Maser Monitoring Project
  Co-advising with Dr. Anita Hafner (University of Sydney)

PROFESSIONAL REFERENCES

Available upon request.

PRESS

Scientists Accidentally Discover Huge Galactic Structure in Space, *Newsweek*; *Popular Science*, 2021
- Popular science article on Busch et al. 2021, discovery of a disk of dark molecular gas in the Outer Galaxy.
Alumni Spotlight: Michael Busch, SESE News, Interview, 2018
- Interview about my undergraduate journey and future plans. ***ASU Astronomy Grad to see the world–and Stars***, ASU Now, Interview, 2016
- highlight of my undergraduate awards and NSF fellowship, undergraduate research and future plans.