William O. **Balmer**

PHOTON HUNTER · FRINGE TRACKER · EXOPLANETEER

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Appointments

Graduate Research Assistant — *Baltimore, MD*
SPACE TELESCOPE SCIENCE INSTITUTE — *Jun. 2021 - present*

Observatory Fellow — *Baltimore, MD*
NASA MARYLAND SPACE GRANT CONSORTIUM — *Sept. 2022 - Jun. 2023*

Undergraduate Research Assistant — *Amherst, MA*
FOLLETTE LAB, AMHERST COLLEGE — *Jun. 2018 - Aug. 2021*

Undergraduate Research Assistant — *Ithaca, NY*
SIOS LAB, CORNELL UNIVERSITY — *Jun. 2020 - Aug. 2020*

Teaching Assistant, Grading Assistant, Observatory Operator — *Amherst, MA*
PHYSICS AND ASTRONOMY DEPARTMENT, AMHERST COLLEGE — *Sept. 2019 - May. 2021*

Education

Johns Hopkins University — *Baltimore, MD*
PH.D CANDIDATE IN ASTROPHYSICS — *May 2023 - present*

- Thesis: *Mapping Giant Planet Dynamics and Atmospheres on the Bleeding Edges of Detectability*
  - Advisor: Laurent Pueyo

Baltimore, MD
MASTERS IN PHYSICS — *Aug. 2021 - Apr. 2023*

- Advisor: Laurent Pueyo
- Completed Graduate Board Oral (qualifying) exam, achieving candidacy May 2nd, 2023
- Courses: *Stellar Structure and Evolution*, *Exoplanets and their Atmospheres*, *Radiative Astrophysics*, *Interstellar Medium and Astrophysical Fluid Dynamics*, *Exoplanets and Planet Formation*, *Fourier Optics and Interferometry in Astronomy*, *Astrophysical Dynamics*

Amherst College — *Amherst, MA*
B.A. *cum laude* IN ASTRONOMY; B.A. *cum laude* IN PHYSICS — *Aug. 2017 - May. 2021*

- Honors thesis: *The Orbit and Hα Variability of the Embedded Accreting Protostellar Companion HD 142527B*
  - Advisor: Katherine Follette
  - Unanimously nominated by the Department of Physics and Astronomy for *summa cum laude* honors
- Three time Amherst Memorial Fellowship awardee (2021, 2022, 2023)

Research Advising

Henry Dennen: "Orbits and dynamical masses of directly imaged planets" — *Undergraduate*
JOHNS HOPKINS UNIVERSITY, SUMMER INTERNSHIP — *June 2024 - present*

Henry is a contributing author on a forthcoming paper from our group as a result of his internship.

Gavin Wang: "A Revised Density for the largest known planet from NEID and TESS" — *Undergraduate*
JOHNS HOPKINS UNIVERSITY, SUMMER INTERNSHIP — *February 2023 - present*

Gavin is leading a forthcoming first author paper as a result of his internship.

Research Interests

I am interested in the direct detection and characterization of exoplanets using optical and infrared observations. I am a specialist in the planning, execution, and analysis of coronagraphic imaging using *JWST*. I am also a "power-user" of the GRAVITY instrument at the Very Large Telescope Interferometer. My work seeks to answer questions like: is our Solar System unique when compared to other systems? How can we improve our methods for directly observing planets? Can we use measurements of the orbits and atmospheres of giant planets as clues to their formation and evolution?

Grants & Awards

$50,000	**James Webb Space Telescope Program DD 4558 (Co-PI)**, NASA	*2024*
$170,704	**James Webb Space Telescope Program GO 3337 (Co-PI)**, NASA	*2024-2025*
$132,841	**Hubble Space Telescope Program GO 17122 (Co-PI)**, NASA	*2023-2024*
$6,000	**NASA WIYN PI Data Award 2023**, NExScI, on behalf of NASA NN-EXPLORE	*2023-2024*
$6,000	**NASA WIYN PI Data Award 2022**, NExScI, on behalf of NASA NN-EXPLORE	*2022-2023*
$18,000	**Owen Scholars Fellowship**, Krieger School of Arts and Sciences, JHU	*2021-2024*
Award	**Amherst Memorial Fellowship (x3)**, Amherst College Board of Trustees	*2021-2023*
Award	**Chambliss Student Poster Award Honorable Mention**, AAS 237th meeting	*2021*
$4,500	**Charles Hamilton Houston Award**, Charles Hamilton Houston Internship Program	*2020*
$3,500	**Gregory S. Call Student Researcher Award**, Gregory S. Call Student Research Program	*2019*
$3,500	**Sarles Fellow Award**, The Sarles Science Fund	*2018*

Observing Programs

* indicates PI contribution

Co-I	GO 6362 | JWST, *"Breaking the degeneracy: substellar anchors for evolutionary models,"* PI: E. Rickman, et al. **(30.3 hours)**	*Cycle 3*
Co-I	GO 6086 | JWST, *"A First Detailed Exploration of Circumplanetary Disk Gas and Dust with NIRSpec and MIRI/MRS Spectroscopy,"* PI: K. Ward-Duong, et al. **(17.4 hours)**	*Cycle 3*
Co-I	GO 5835 | JWST, *"Into The Spotlight: Unveiling Wide-Separation Sub-Jupiters for Future JWST Characterization,"* PI: A. Carter, et al. **(94.9 hours)**	*Cycle 3*
Co-I	GO 5342 | JWST, *"Spectroscopic characterization of the lowest-mass imaged Jupiter analog,"* PI: J. Xuan, et al. **(13.2 hours)**	*Cycle 3*
Co-I	GO 4758 | JWST, *"From Day to Season: Constraining the Rotation Period and Obliquity of Beta Pic b with Time-resolved High-contrast Imaging,"* PI: Y. Zhou, et al. **(23.9 hours)**	*Cycle 3*
***Co-PI**	DD 4558 | JWST, *"Establishing the Formation of AF Lep b with NIRCam: The Lowest-Mass Imaged Exoplanet with a Dynamical Mass,"* Co-PIs: K. Franson, W. Balmer, et al. **(6.4 hours)**	*Cycle 2*
Co-I	GO 4535 | JWST, *"Follow-up Observations of NIRCam Sources in the Planetary System HR8799,"* PI: C. Beichman, et al. **(4.5 hours)**	*Cycle 3*
Co-I	GO 4534 | JWST, *"Exoplanet search around Altair,"* PI: C. Beichman, et al. **(7.2 hours)**	*Cycle 3*
***PI**	VLTI/GRAVITY | ESO, *"Investigating the 25 Myr L-T transition with VLTI/GRAVITY observations of the new planet AF Lep b,"* PI: W. Balmer, et al. **(9 hours)**	*P112*
***Co-PI**	GO 3337 | JWST, *"Solving a Solar Neighborhood Crime Scene by Imaging 14 Her c,"* Co-PIs: D. Bardalez Gagliuffi, W. Balmer, et al. **(7.6 hours)**	*Cycle 2*
Co-I	GO 4050 | JWST, *"Uncharted Worlds: Towards a Legacy of Direct Imaging of Sub-Jupiter Mass Exoplanets,"* PI: A. Carter, et al. **(46.6 hours)**	*Cycle 2*
***PI**	VLTI/GRAVITY | ESO, *"Monitoring 51 Eri b for a perturbing inner companion,"* PI: W. Balmer, et al. **(15 hours)**	*P111-114*
Co-I	SOAR 4.1m | NOIRLAB, *"Testing planetary formation paradigms via SOAR-HST observations of an accreting planet,"* PI: C. Robinson **1 night)**	*Cycle 30*
***Co-PI**	GO 17122 | HST, *"Testing Planetary Formation Mechanisms through the First FUV - Optical Spectrum of a Young, Accreting Planet,"* Co-PIs: C. Robinson, W. Balmer, et al. **(9 orbits)**	*Cycle 30*
Co-I	GO 17092 (CAL) | HST, *"Calibrating STIS Coronagraphic Spectroscopy for High Contrast Observations,"* PI: K. Ward-Duong, et al. **(6 orbits)**	*Cycle 30*
Co-I	GO 17162 | HST, *"The HST/JWST synergy: A deep dive into the NUV with WASP-39b to answer key formation questions,"* PI: D. Sing, et al. **(24 orbits)**	*Cycle 30*
***PI**	VLTI/GRAVITY | ESO, *"Characterizing the target of a novel JWST Cycle 1 GO observation with VLTI/GRAVITY,"* PI: W. Balmer, et al. **(3 hours)**	*P109*
***PI**	WIYN 3.5m | NNExplore, *"A precision mass measurement of the most inflated hot-Saturn HAT-P-67 b,"* PI: W. Balmer, et al. **(2.4 nights)**	*2022A*
***PI**	SOAR 4.1m | NOIRLAB, *"Characterization of exoGRAVITY Host Stars (GHOSTS): in the Southern Hemisphere,"* PI: W. Balmer, et al. **(2 nights)**	*2022A*
***PI**	ARC 3.5m | Apache Point Observatory, *"Characterization of exoGRAVITY Host Stars (GHOSTS): Northern Hemisphere,"* PI: W. Balmer **(24 hrs)**	*2021, Q4*

Refereed Publications

24 refereed papers • 266 unique refereed citations • h-index = 11 • i10-index = 11 • from NASA ADS August '24

First Author

5. **Balmer, W. O**, Kammerer, J., Pueyo, L., et al. (submitted). *JWST-TST High Contrast: Living on the Wedge, or, NIRCam Bar Coronagraphy Reveals CO_2 in the HR 8799 and 51 Eri Exoplanets' Atmospheres*
4. **Balmer, W. O.**, Franson, K., Chomez, A., et al. (accepted) *AJ*, arXiv:2411.05917. *VLTI/GRAVITY Observations of AF Lep b: Preference for Circular Orbits, Cloudy Atmospheres, and a Moderately Enhanced Metallicity*
3. **Balmer, W. O.**, Pueyo, L., Lacour, S., et al. (2024) *AJ*, 167, 64. *VLTI/GRAVITY Provides Evidence the Young, Substellar Companion HD 136164 Ab Formed Like a "Failed Star"*
2. **Balmer, W. O.**, Pueyo, L., Stolker, T., et al. (2023) *ApJ*, 956, 99. *VLTI/GRAVITY Observations and Characterization of the Brown Dwarf Companion HD 72946 B*
1. **Balmer, W. O.**, Follette, K. B., Close, L. M., et al. (2022) *AJ*, 164, 29. *Improved Orbital Constraints and Hα Photometric Monitoring of the Directly Imaged Protoplanet Analog HD 142527 B*

Second- or third- author

2. Franson, K., Balmer, W. O., Bowler, B. P., et al. (2024) *ApJL*, 974, L11. *JWST/NIRCam 4–5 μm Imaging of the Giant Planet AF Lep b*
1. Blunt, S., **Balmer, W. O.**, Wang, J. J. et al. (2023) *First VLTI/GRAVITY Observations of HIP 65426 b: Evidence for a Low or Moderate Orbital Eccentricity*

Co-author

19. Hoch, K. K. W., Theissen, C. A., Barman, T. S., et al. (2024) *arXiv*, arXiv:2408.03830. *JWST-TST High Contrast: Spectroscopic Characterization of the Benchmark Brown Dwarf HD 19467 B with the NIRSpec Integral Field Spectrograph*
18. Ruffio, J.-B., Perrin, M. D., Hoch, K. K. W., et al. (2024) *AJ*, 168, 73. *JWST-TST High Contrast: Achieving Direct Spectroscopy of Faint Substellar Companions Next to Bright Stars with the NIRSpec Integral Field Unit*
17. Winterhalder, T. O., Lacour, S., Mérand, A., et al. (2024) *A&A*, 688, A44. *Combining Gaia and GRAVITY: Characterising five new directly detected substellar companions*
16. Kammerer, J., Lawson, K., Perrin, M. D., et al. (2024) *AJ*, 168, 51. *JWST-TST High Contrast: JWST/NIRCam Observations of the Young Giant Planet β Pic b*
15. Chai, Y., Chen, C. H., Worthen, K., et al. (2024) *arXiv*, arXiv:2408.11692. *A JWST MIRI MRS View of the η Tel Debris Disk and its Brown Dwarf Companion*
14. Nowak, M., Lacour, S., Abuter, R., et al. (2024) *A&A*, 687, A248. *Catalogue of dual-field interferometric binary calibrators*
13. Nasedkin, E., Mollière, P., Lacour, S., et al. (2024) *A&A*, 687, A298. *Four-of-a-kind? Comprehensive atmospheric characterisation of the HR 8799 planets with VLTI/GRAVITY*
12. Pourré, N., Winterhalder, T. O., Le Bouquin, J.-B., et al. (2024) *A&A*, 686, A258. *High contrast at short separation with VLTI/GRAVITY: Bringing Gaia companions to light*
11. Petrus, S., Whiteford, N., Patapis, P., et al. (2024) *ApJL*, 966, L11. *The JWST Early Release Science Program for Direct Observations of Exoplanetary Systems. V. Do Self-consistent Atmospheric Models Represent JWST Spectra? A Showcase with VHS 1256–1257 b*
10. Worthen, K., Chen, C. H., Law, D. R., et al. (2024) *ApJ*, 964, 168. *MIRI MRS Observations of β Pictoris. I. The Inner Dust, the Planet, and the Gas*
9. Sallum, S., Ray, S., Kammerer, J., et al. (2024) *ApJL*, 963, L2. *The JWST Early Release Science Program for Direct Observations of Exoplanetary Systems. IV. NIRISS Aperture Masking Interferometry Performance and Lessons Learned*

8. Ray, S., Sallum, S., Hinkley, S., et al. (2023) *arXiv*, arXiv:2310.11508. *The JWST Early Release Science Program for Direct Observations of Exoplanetary Systems III: Aperture Masking Interferometric Observations of the star HIP 65426 at* $3.8\,\mu\mathrm{m}$

7. Grant, D., Lewis, N. K., Wakeford, H. R., et al. (2023) *ApJL*, 956, L32. *JWST-TST DREAMS: Quartz Clouds in the Atmosphere of WASP-17b*

6. Carter, A. L., Hinkley, S., Kammerer, J., et al. (2023) *ApJL*, 951, L20. *The JWST Early Release Science Program for Direct Observations of Exoplanetary Systems I: High-contrast Imaging of the Exoplanet HIP 65426 b from 2 to 16 μm*

5. Follette, K. B., Close, L. M., Males, J. R., et al. (2023) *AJ*, 165, 225. *The Giant Accreting Protoplanet Survey (GAPlanetS)-Results from a 6 yr Campaign to Image Accreting Protoplanets*

4. Hinkley, S., Lacour, S., Marleau, G.-D., et al. (2023) *A&A*, 671, L5. *Direct discovery of the inner exoplanet in the HD 206893 system. Evidence for deuterium burning in a planetary-mass companion*

3. Miles, B. E., Biller, B. A., Patapis, P., et al. (2023) *ApJL*, 946, L6. *The JWST Early-release Science Program for Direct Observations of Exoplanetary Systems II: A 1 to 20 μm Spectrum of the Planetary-mass Companion VHS 1256-1257 b*

2. Adams Redai, J. I., Follette, K. B., Wang, J., et al. (2023) *AJ*, 165, 57. *The Giant Accreting Protoplanet Survey (GAPlanetS): Optimization Techniques for Robust Detections of Protoplanets*

1. Betti, S. K., Follette, K. B., Ward-Duong, K., et al. (2022) *ApJL*, 935, L18. *Near-infrared Accretion Signatures from the Circumbinary Planetary-mass Companion Delorme 1 (AB)b*

Presentations

Conference talks

- **"Long baseline optical interferometry of exoplanets and brown dwarfs"**, Chesapeake Bay Area Exoplanet Meeting #11 — *May 2024*
- **"Direct Detection and Characterization of Ice-line Giants with Optical Interferometry"**, Pathways to Characterizing Non-Transiting Planets, SEEC Symposium 2024 — *April 2024*
- **"The Unexpected Detection of HR8799e with NIRCam Coronagraphy and Implications for Cycle 3"**, Planetary Systems and the Origins of Life in the Era of *JWST*, STScI Spring Symposium 2023 — *May 2023*
- **"Unprecedented precision: using VLTI/GRAVITY jointly with Gaia to characterize substellar companions near and far, young and old"**, Cool Stars 21 Splinter Session — *Aug. 2022*

Colloquia & Seminars

- **STScI-JHU ExoJamboree**, Baltimore, MD — *Nov. 2024*
- **Carnegie EPL Astronomy Seminar**, Washington DC — *Oct. 2024*
- **OCA Protoplanets Group Meeting**, Nice, France — *Jun. 2024*
- **ESO Garching Star and Planet Formation Seminar**, Garching, Germany — *Nov. 2023*
- **ESO Garching Stellar Coffee and Planetary Tea**, Garching, Germany — *Nov. 2023*
- **ExoGRAVITY Collaboration Workshop**, Heidelberg, Germany — *Nov. 2023*
- `petitRADTRANS` **Collaboration Workshop**, Heidelberg, Germany — *Nov. 2023*
- **American Museum of Natural History Astronomy Colloquium**, New York City, NY — *Feb. 2023*
- **STScI HotSci 2022**, Baltimore, MD — *August 17th, 2022*

Poster presentations

- **"Constraining the Atmosphere and Interior of the Directly Imaged Planet AF Leporis b with VLTI/GRAVITY"**, Extreme Solar Systems V — *March 2024*
- **"The orbit and Hα variability of HD 142527B"**, Coolstars 21 — *July 2022*
- **"Charaterization of the L-type Brown Dwarf Companion to the Nearby Solar-type Star HD 72946 with VLTI/GRAVITY, VLT/SPHERE, and RVs"**, In The Spirit of Lyot — *June 2022*
- **"The orbit and Hα variability of HD 142527B"**, STScI Spring Symposium — *April 2021*

Outreach & Service

Outreach — Observatory Open Houses and K-12 Tours (as Fellow 2022-23 & volunteer to present), *MDSGO* — *2022 - present*
Outreach — Invited talk, *North County High School* — *June 2023*
Outreach — Invited talk, *Howard Astronomical League* — *Jun. 2022*
Outreach — Invited talk, *Balticon 56* — *May 2022*
Sci-Comm — Author, *Astrobites* — *2019 - 2021*
Sci-Comm — Astronomy Editor, *The Amherst STEM Network* — *2019 - 2021*
Volunteer — Observatory Operator, *Amherst College Observatory* — *2021*
Outreach — Invited talk, *UMass Amherst Astronomy Club* — *Apr. 2021*

Code

</> Code I manage:

- `backtracks`: Relative motion of background sources with proper motion and parallax
- `stellaluna`: My own pedagogical zero-age main sequence stellar structure code

Code I contribute to

- `species`: Toolkit for atmospheric characterization of directly imaged planets
- `spaceKLIP`: High contrast imaging routines for JWST data
- `petitRADTRANS`: Spectral modeling and atmospheric retrieval code