

Aarynn L. Carter

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Career Summary

As a Postdoctoral Scholar at UC Santa Cruz I use the most advanced observatories to detect exoplanets through direct imaging, and characterise exoplanetary atmospheres through both direct and indirect observational methods. During my PhD, I led a comprehensive study of the atmosphere of the hot-Jupiter WASP-6 b using observations from *HST*, *VLT*, *TESS*, and *Spitzer*. Additionally, I performed critical developmental work on the *JWST* Early Release Science exoplanet programs. Since joining UC Santa Cruz I have both led and contributed to a range of software development for the simulation and analysis of *JWST* observations. More recently, I have lead, or co-lead, some of the earliest *JWST* observations of exoplanets, resulting in the first direct detection of an exoplanet beyond 5 μm , and the first definitive detection of CO_2 in an exoplanet atmosphere.

Research Employment

2020 - Current | Postdoctoral Scholar, University of California, Santa Cruz
Mentors: Prof. Andy Skemer & Prof. Natalie Batalha

Education

2016 - 2020 | PhD Physics, University of Exeter, *Towards Exoplanetary Science in the Era of JWST*
Advisors: Prof. Sasha Hinkley & Prof. David Sing

2012 - 2016 | BSc MPhys (First Class Honours), Physics, University of Warwick

Observational Programs

PI: A. Carter | Gemini GN(S)-2022A-Q-132(139), 9.5 Hours, *Simultaneous, multi-wavelength variability monitoring of a key directly imaged exoplanet analogue in support of JWST ERS observations*

PI: S. Ray | VLT 108.22CD, 18 Hours, *Benchmark PSF References for the JWST Interferometer*

PI: N. Whiteford | NTT 108.22BH, 3 Nights, *VHS 1256ABb SofI Variability Proposal*

PI: P. Loyd | HST GO-16731, 12 Orbits, *Leveraging High Radial Velocities to Get to the Core of Planetary Lyman-alpha Transits*

PI: B. Biller | TNG OPTICON-21B/031, 1 Night, *Multi-wavelength variability monitoring of a key directly imaged exoplanet analogue.*

PI: S. Hinkley | JWST GO-02538, 24 Hours, *Using JWST to Search for Planetary Sculptors in an ALMA-Selected Sample of Debris Disks*

PI: A. Skemer | JWST GO-02327, 14 Hours, *Water Ice Clouds and Weather on the Coldest Brown Dwarf*

PI: E. Matthews | JWST GO-02243, 14 Hours, *A Direct Detection of the Closest Jupiter Analog with JWST/MIRI*

PI: S. Marino | JWST GO-01668, 11 Hours, *Searching for Low Mass Planets in Debris Disk Gaps*

PI: N. Nikolov | HST GO-15469, 10 Orbits, *Characterizing a new prototype Saturn-mass exoplanet with the clearest atmosphere yet.*

PI: S. Hinkley | JWST ERS-1386, 68 Hours, *High Contrast Imaging of Exoplanets and Exoplanetary Systems with JWST.*

PI: N. Batalha | JWST ERS-1366, 81 Hours, *The Transiting Exoplanet Community Early Release Science Program.*

PI: T. Evans | HST GO-15135, 10 Orbits, *An exoplanet with a stratosphere: seeking the unknown absorber.*

PI: N. Nikolov | VLT 199.C-0467, 208 Hours, *From hot gas-giants to cooler rocky exo-Earths: The first large-scale comparative exoplanet atmospheric survey with FORS2.*

Approved Research Grants

2022	JWST Cycle 1 GO-02538, USA Principal Investigator – \$94,969
2022	JWST Cycle 1 GO-02243, USA Principal Investigator – \$90,439
2022	JWST Cycle 1 GO-02538, USA Principal Investigator – \$56,678

Conferences & Professional Talks

Nov 2022	UT Austin Astronomy Colloquium, Austin, USA - (Invited Talk)
Oct 2022	STScI JWWebinar, Virtual - (Service Talk)
Sep 2022	NASA JPL Exoplanet Talk Series, Virtual - (Invited Talk)
Jun 2022	ExoExplorer Science Series - (\$1,000 Paid Talk)
May 2022	Exoplanets IV, Las Vegas, USA - (Contributed Talk)
Mar 2022	Exoplanets, Star, and Planet Formation Seminar Series, STScI, USA - (Invited Talk)
Feb 2022	UCSC Planetary Lunch (PLUNCH), Santa Cruz, USA - (Invited Talk)
Sep 2021	European Planetary Science Congress 2021, Virtual Conference - (Contributed Talk)
Aug 2021	SPIE Optics & Photonics 2021, San Diego, USA - (Contributed Talk)
Jun 2021	AAS 238, Virtually Anywhere - (Contributed Talk)
Jan 2021	RAS Specialist Discussion, London, UK - (Invited Talk)
Sep 2020	Bay Area Exoplanet Meeting, Online - (Contributed Talk)
Jul 2020	Exo-Webbinar: Online Talk Series - (Contributed Talk)
Mar 2020	JWST Master Class Workshop, Exeter, UK - (Lead Organiser & Speaker)
Jul 2019	Bay Area Exoplanet Meeting, Santa Cruz, USA - (Contributed Talk)
Sep 2018	University of Exeter Seminar Series, Exeter, UK - (Invited Talk)
Mar 2018	UK Exoplanet Meeting, Oxford, UK - (Keynote Talk)

Service & Honours

2022	NASA ExoExplorer Cohort Member
2022 - Current	Panelist for NASA APRA+SAT
2022 - Current	Reviewer for NASA FINESST
2021 - Current	UCSC Astronomy & Astrophysics Diversity, Equity, and Inclusion Committee Member
2021 - Current	Reviewer for AAS Journals
2021 - 2022	UCSC Astronomy & Astrophysics Colloquium Committee Member

Software Development

PanCAKE	Simulation tool for <i>JWST</i> coronagraphic observations (Major Update Lead)
Eureka!	Data analysis pipeline for <i>HST</i> / <i>JWST</i> time series observations
spaceKLIP	Data analysis pipeline for <i>JWST</i> coronagraphic observations (Co-Lead Developer)

Teaching

Lab Instructor	University of Exeter – NSC1004, Experimental Science
Lab Instructor	University of Exeter – PHY1027, Practical Physics I

Selected Publications

- [9] Jens Kammerer, Julien Girard, **Aarynn L. Carter**, Marshall D. Perrin, Rachel Cooper, et al. “Performance of near-infrared high-contrast imaging methods with *JWST* from commissioning”. In: *arXiv e-prints*, arXiv:2208.00996 (Aug. 2022).
- [8] The *JWST* Transiting Exoplanet Community Early Release Science Team, Eva-Maria Ahrer, Lili Alderson, Natalie M. Batalha, **including Aarynn. L Carter (co-lead author)**, et al. “Identification of carbon dioxide in an exoplanet atmosphere”. In: *arXiv e-prints*, arXiv:2208.11692 (Aug. 2022).
- [7] **Aarynn L. Carter**, Sasha Hinkley, Jens Kammerer, Andrew Skemer, Beth A. Biller, et al. “The *JWST* Early Release Science Program for Direct Observations of Exoplanetary Systems I: High Contrast Imaging of the Exoplanet HIP 65426 b from 2-16 μm ”. In: *arXiv e-prints*, arXiv:2208.14990 (Aug. 2022).

- [6] Taylor J. Bell, Eva-Maria Ahrer, Jonathan Brande, **Aarynn L. Carter**, Adina D. Feinstein, et al. “Eureka!: An End-to-End Pipeline for JWST Time-Series Observations”. In: *arXiv e-prints*, arXiv:2207.03585 (July 2022).
- [5] Sasha Hinkley, **Aarynn L. Carter**, Shrishmoy Ray, Andrew Skemer, Beth Biller, et al. “The JWST Early Release Science Program for the Direct Imaging & Spectroscopy of Exoplanetary Systems”. In: *arXiv e-prints*, arXiv:2205.12972 (May 2022).
- [4] **Aarynn L. Carter**, Andrew J. I. Skemer, Camilla Danielski, Jarron Leisenring, Jason J. Wang, et al. “Simulating JWST high contrast observations with PanCAKE”. In: *Techniques and Instrumentation for Detection of Exoplanets X*. Vol. 11823. International Society for Optics and Photonics. SPIE, Sept. 2021, pp. 162–178.
- [3] **Aarynn L. Carter**, Sasha Hinkley, Mariangela Bonavita, Mark W. Phillips, Julien H. Girard, et al. “Direct imaging of sub-Jupiter mass exoplanets with James Webb Space Telescope coronagraphy”. In: *Monthly Notices of the Royal Astronomical Society* 501.2 (Feb. 2021), pp. 1999–2016. arXiv: 2011.07075.
- [2] **Aarynn L. Carter**, Nikolay Nikolov, David K. Sing, Munazza K. Alam, Jayesh M. Goyal, et al. “Detection of Na, K, and H₂O in the hazy atmosphere of WASP-6b”. In: *Monthly Notices of the Royal Astronomical Society* 494.4 (June 2020), pp. 5449–5472. arXiv: 1911.12628.
- [1] Benjamin Drummond, **Aarynn L. Carter**, Eric Hébrard, Nathan J. Mayne, David K. Sing, et al. “The carbon-to-oxygen ratio: implications for the spectra of hydrogen-dominated exoplanet atmospheres”. In: *Monthly Notices of the Royal Astronomical Society* 486.1 (June 2019), pp. 1123–1137. arXiv: 1903.10997.

All Publications

- [23] Brittany E. Miles, Beth A. Biller, Polychronis Patapis, Kadin Worthen, Emily Rickman, et al. “The JWST Early Release Science Program for Direct Observations of Exoplanetary Systems II: A 1 to 20 Micron Spectrum of the Planetary-Mass Companion VHS 1256-1257 b”. In: *arXiv e-prints*, arXiv:2209.00620 (Sept. 2022).
- [22] Nikolay K. Nikolov, David K. Sing, Jessica J. Spake, Barry Smalley, Jayesh M. Goyal, et al. “Solar-to-supersolar sodium and oxygen absolute abundances for a ‘hot Saturn’ orbiting a metal-rich star”. In: 515.2 (Sept. 2022), pp. 3037–3058. arXiv: 2206.00017.
- [21] Jens Kammerer, Julien Girard, **Aarynn L. Carter**, Marshall D. Perrin, Rachel Cooper, et al. “Performance of near-infrared high-contrast imaging methods with JWST from commissioning”. In: *arXiv e-prints*, arXiv:2208.00996 (Aug. 2022).
- [20] Julien H. Girard, Jarron Leisenring, Jens Kammerer, Mario Gennaro, Marcia Rieke, et al. “JWST/NIRCam Coronagraphy: Commissioning and First On-Sky Results”. In: *arXiv e-prints*, arXiv:2208.00998 (Aug. 2022).
- [19] The JWST Transiting Exoplanet Community Early Release Science Team, Eva-Maria Ahrer, Lili Alderson, Natalie M. Batalha, **including Aarynn. L Carter (co-lead author)**, et al. “Identification of carbon dioxide in an exoplanet atmosphere”. In: *arXiv e-prints*, arXiv:2208.11692 (Aug. 2022).
- [18] **Aarynn L. Carter**, Sasha Hinkley, Jens Kammerer, Andrew Skemer, Beth A. Biller, et al. “The JWST Early Release Science Program for Direct Observations of Exoplanetary Systems I: High Contrast Imaging of the Exoplanet HIP 65426 b from 2-16 μm ”. In: *arXiv e-prints*, arXiv:2208.14990 (Aug. 2022).
- [17] Taylor J. Bell, Eva-Maria Ahrer, Jonathan Brande, **Aarynn L. Carter**, Adina D. Feinstein, et al. “Eureka!: An End-to-End Pipeline for JWST Time-Series Observations”. In: *arXiv e-prints*, arXiv:2207.03585 (July 2022).
- [16] Sasha Hinkley, **Aarynn L. Carter**, Shrishmoy Ray, Andrew Skemer, Beth Biller, et al. “The JWST Early Release Science Program for the Direct Imaging & Spectroscopy of Exoplanetary Systems”. In: *arXiv e-prints*, arXiv:2205.12972 (May 2022).
- [15] Nikolay Nikolov, Gracjan Maciejewski, Savvas Constantinou, Nikku Madhusudhan, Jonathan J. Fortney, et al. “Ground-based Transmission Spectroscopy with VLT FORS2: Evidence for Faculae and Clouds in the Optical Spectrum of the Warm Saturn WASP-110b”. In: *Astrophysical Journal* 162.3, 88 (Sept. 2021), p. 88. arXiv: 2105.06522.
- [14] **Aarynn L. Carter**, Andrew J. I. Skemer, Camilla Danielski, Jarron Leisenring, Jason J. Wang, et al. “Simulating JWST high contrast observations with PanCAKE”. In: *Techniques and Instrumentation for Detection of Exoplanets X*. Vol. 11823. International Society for Optics and Photonics. SPIE, Sept. 2021, pp. 162–178.

- [13] Petros Spyros, Nikolay Nikolov, John Southworth, Savvas Constantinou, Nikku Madhusudhan, et al. "Transmission spectroscopy with VLT FORS2: a featureless spectrum for the low-density transiting exoplanet WASP-88b". In: *Monthly Notices of the Royal Astronomical Society* (July 2021). arXiv: 2106.14808.
- [12] **Aarynn L. Carter**, Sasha Hinkley, Mariangela Bonavita, Mark W. Phillips, Julien H. Girard, et al. "Direct imaging of sub-Jupiter mass exoplanets with James Webb Space Telescope coronagraphy". In: *Monthly Notices of the Royal Astronomical Society* 501.2 (Feb. 2021), pp. 1999–2016. arXiv: 2011.07075.
- [11] Jessica J. Spake, David K. Sing, Hannah R. Wakeford, Nikolay Nikolov, Thomas Mikal-Evans, et al. "Abundance measurements of H₂O and carbon-bearing species in the atmosphere of WASP-127b confirm its supersolar metallicity". In: *Monthly Notices of the Royal Astronomical Society* 500.3 (Jan. 2021), pp. 4042–4064. arXiv: 1911.08859.
- [10] Jamie Wilson, Neale P. Gibson, Nikolay Nikolov, Savvas Constantinou, Nikku Madhusudhan, et al. "Ground-based transmission spectroscopy with FORS2: A featureless optical transmission spectrum and detection of H₂O for the ultra-hot Jupiter WASP-103b". In: *Monthly Notices of the Royal Astronomical Society* 497.4 (Aug. 2020), pp. 5155–5170. arXiv: 2007.13510.
- [9] **Aarynn L. Carter**, Nikolay Nikolov, David K. Sing, Munazza K. Alam, Jayesh M. Goyal, et al. "Detection of Na, K, and H₂O in the hazy atmosphere of WASP-6b". In: *Monthly Notices of the Royal Astronomical Society* 494.4 (June 2020), pp. 5449–5472. arXiv: 1911.12628.
- [8] Thomas Mikal-Evans, David K. Sing, Jayesh M. Goyal, Benjamin Drummond, **Aarynn L. Carter**, et al. "An emission spectrum for WASP-121b measured across the 0.8–1.1 μm wavelength range using the Hubble Space Telescope". In: *Monthly Notices of the Royal Astronomical Society* 488.2 (Sept. 2019), pp. 2222–2234. arXiv: 1906.06326.
- [7] Benjamin Drummond, **Aarynn L. Carter**, Eric Hébrard, Nathan J. Mayne, David K. Sing, et al. "The carbon-to-oxygen ratio: implications for the spectra of hydrogen-dominated exoplanet atmospheres". In: *Monthly Notices of the Royal Astronomical Society* 486.1 (June 2019), pp. 1123–1137. arXiv: 1903.10997.
- [6] Jacob L. Bean, Kevin B. Stevenson, Natalie M. Batalha, Zachory Berta-Thompson, Laura Kreidberg, et al. "The Transiting Exoplanet Community Early Release Science Program for JWST". In: *Publications of the Astronomical Society of the Pacific* 130.993 (Nov. 2018), p. 114402. arXiv: 1803.04985.
- [5] S. Lines, J. Manners, N. J. Mayne, J. Goyal, **A. L. Carter**, et al. "Exonephology: transmission spectra from a 3D simulated cloudy atmosphere of HD 209458b". In: *Monthly Notices of the Royal Astronomical Society* 481.1 (Nov. 2018), pp. 194–205. arXiv: 1808.05887.
- [4] N. Nikolov, D. K. Sing, J. J. Fortney, J. M. Goyal, B. Drummond, et al. "An absolute sodium abundance for a cloud-free 'hot Saturn' exoplanet". In: *Nature* 557.7706 (May 2018), pp. 526–529. arXiv: 1806.06089.
- [3] Jayesh M. Goyal, Nathan Mayne, David K. Sing, Benjamin Drummond, Pascal Tremblin, et al. "A library of ATMO forward model transmission spectra for hot Jupiter exoplanets". In: *Monthly Notices of the Royal Astronomical Society* 474.4 (Mar. 2018), pp. 5158–5185. arXiv: 1710.10269.
- [2] Benjamin Drummond, N. J. Mayne, James Manners, **Aarynn L. Carter**, Ian A. Boutle, et al. "Observable signatures of wind-driven chemistry with a fully consistent three dimensional radiative hydrodynamics model of HD 209458b". In: *Astrophysical Journal Letters* 855.2 (Feb. 2018), p. L31. arXiv: 1802.09222.
- [1] H. R. Wakeford, D. K. Sing, D. Deming, N. K. Lewis, J. Goyal, et al. "The Complete Transmission Spectrum of WASP-39b with a Precise Water Constraint". In: *The Astronomical Journal* 155.1, 29 (Jan. 2018), p. 29. arXiv: 1711.10529.