

Matthew E. Orr | Curriculum Vitae

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Education

California Institute of Technology	Pasadena, CA
<i>Ph.D. Physics, Thesis Advisor: Dr. Philip F. Hopkins</i>	<i>June 2019</i>
Dissertation Title: "Spatially Resolved Star Formation in Cosmological Zoom-in Simulations: Understanding the Role of Feedback in Scaling Relations" (Defended May 28, 2019).	
<i>M.S. Physics</i>	<i>June 2017</i>
University of Southern California	Los Angeles, CA
<i>B.S. Physics, Minor in Astronomy, Magna Cum Laude</i>	<i>May 2014</i>
La Cañada High School	La Cañada Flintridge, CA

Experience

Flatiron Institute & Rutgers University	CCA, Rutgers
<i>Joint Rutgers–Flatiron Research Fellow</i>	<i>September 2020 – Present</i>
Joint postdoctoral fellowship appointment at Rutgers University and the Flatiron Institute Center for Computational Astrophysics. Focus on the connections between star formation and feedback, and galaxy formation and evolution, using a combination of cosmological zoom-in simulations (the FIRE-2 suite), data-driven methods and analytic work.	
TAPIR, Hopkins Group (FIRE Collaboration)	Caltech
<i>Postdoctoral Scholar in Theoretical Astrophysics</i>	<i>July 2019 – July 2020</i>
<i>National Science Foundation Graduate Research Fellow</i>	<i>September 2014 – June 2019</i>
<i>Rose Hills Graduate Research Fellow</i>	<i>September 2014 – August 2015</i>
Graduate studies in theoretical astrophysics combining analytic work with simulations under the advisement of Dr. Philip F. Hopkins. Investigated the physical origins for spatially resolved star formation and galaxy evolution relations with the Feedback in Realistic Environments (FIRE) simulations, and produced synthetic observations of cosmological zoom-in simulations to connect theory with the next generation of high-resolution galaxy studies.	
NASA Jet Propulsion Laboratory – California Institute of Technology	JPL
<i>JPL Science Affiliate – Astronomy, Physics and Space Technology</i>	<i>April 2018 – July 2020</i>
<i>JPL SURF Student & Year-round Intern</i>	<i>May 2013 – July 2014</i>
Developed a chemistry and radiative transfer pipeline for synthetic observations of the FIRE simulations, making use of the CHIMES chemistry & RADMC3D radiative transfer codes, and studied CO, C, and C ⁺ emission from the FIRE spiral galaxy sample. Also interned as an undergraduate, modeling observations from a photodissociation region in the Taurus molecular cloud taken with Herschel and the Five College Radio Astronomy Observatory, using chemical network & radiative transfer codes, with Drs. Paul Goldsmith and Jorge Pineda.	
USAF Research Labs Collaborative High Altitude Flow Facility	USC, AFRL
<i>Research Assistant (Civilian Contractor)</i>	<i>December 2010 – May 2013</i>
Research with Edwards AFB Advanced Concepts Division (Propulsion Directorate) with Drs. Markus Young, David Sharfe and Matthew Gilpin, involving the design and fabrication of a bimodal latent-heat energy storage, solar-thermal power and propulsion system for small satellites, using molten Boron and Silicon. Built a facility-class 1.8 meter solar furnace for on-sun testing, calculated freezing surface contours in constrained geometries in molten Silicon and heat transfer analysis for thermal shielding. Resulted in several internal AFRL technical reports (Distribution C).	
Rhodes Helioseismology Group	USC, Mt. Wilson Observatory
<i>Research Assistant and Telescope Operator</i>	<i>May 2012 – May 2013</i>
Operated the Mt. Wilson 60' Solar Telescope, analyzing of Solar sub-surface flows, under the direction of Dr. Edward Rhodes. Imaged Solar active-regions for Mt. Wilson Observatory historical sunspot archive using a heritage camera.	

Science Outreach & Miscellaneous.....

On-Set Rocketry Consultant for Television and Film Paramount Studios

Science Consultant on CBS' Strange Angel, Seasons 1 & 2 *January – June 2018, 2019*

On-set consultant for the rocketry-related aspects of CBS' Strange Angel, based on the book of the same name by George Pendle. Helped to ensure the most realistic depiction of early rocketry and its contemporary physics, including background items, early test setups, and actors' interactions with rockets and the science behind them.

Caltech Astro Outreach Caltech

Graduate Student Volunteer, Speaker *June 2016 – July 2020*

Volunteer for Astronomy department outreach events throughout the academic year and summer. Involvement includes being a telescope operator for stargazing nights, Q&A panelist and one-time lecturer for the public lecture series, and general volunteer for Astronomy on Tap events.

USC Rocket Propulsion Laboratory USC

Lab Lead *August 2010 – December 2012*

Coordinated lab work, as lab lead. Projects included: Silver Spur 3, Traveler Static Fire, Del Grande Mk. II, Avionics Test Vehicles I & II, Traveler Mk. I – all minimum-diameter, composite-case flight vehicles and static ground tests, with solid rocket motors ranging in size from O-4000 to R-18,000. All led up to Traveler Mk. I, the lab's single-stage ballistic space-shot attempt (Mach 6, max. altitude 491,000 feet). Work included carbon fiber, fiberglass, Kevlar, and cork composites layups (wet & prepreg), machining, fabrication, assembly and integration of the lab's solid motors.

Leadership & Service.....

NSF Astronomy & Astrophysics Research Grant Panel NSF

Panelist *April 2022*

Flatiron Institute ISM Salon CCA

Organizer/Feedback Discussion Lead *March 2022 – Present*

Cahill Astronomy Galaxies arXiv Discussion Caltech

Organizer/Discussion Lead *August 2018 – March 2020*

Caltech Graduate Title IX Advisory Board Caltech

Graduate Student Member *September 2017 – June 2019*

Caltech Board of Trustees Student Experience Committee Caltech

Graduate Student Representative *July 2016 – April 2019*

Caltech Graduate Student Council Caltech

Physics Option Representative *June 2016 – June 2019*

Publications & Strategic Communications Chair *June 2016 – May 2018*

Graduate Dean's Advisory Council Caltech

Chairman *January 2016 – June 2019*

Publications & Presentations

First Author Publications.....

1. **Orr, M.** and Rennehan, D. (2024). How the Cookie Crumbles: A Model for Star-forming Clumps in High-redshift Disk Galaxies, arXiv:2410.23337.
2. **Orr, M.**, Burkhart, B., Lu W., et al. (2024). Objects May Be Closer Than They Appear: Significant Host Galaxy Dispersion Measures of Fast Radio Bursts in Zoom-in Simulations, ApJL 972, L26.
3. **Orr, M.**, Burkhart, B., Wetzel, A., et al. (2023). Spiral Arms are Metal Freeways: Azimuthal Gas-Phase Metallicity Variations in Simulated Cosmological Zoom-in Flocculent Disks, MNRAS 521, 3708.
4. **Orr, M.**, Fielding, D., Hayward, C., & Burkhart, B. (2022). Bursting Bubbles: Feedback from Clustered SNe and the Trade-off Between Turbulence and Outflows, ApJ 932, 88.
5. **Orr, M.**, Fielding, D., Hayward, C., & Burkhart, B. (2022). Bursting Bubbles: Clustered Supernova Feedback in Local and High-redshift Galaxies, ApJL 924, L28.
6. **Orr, M.**, Hatchfield, H., Battersby, C., et al. (2021). Fiery Cores: Bursty and Smooth Star Formation

Distributions across Galaxy Centers in Cosmological Zoom-in Simulations, *ApJL* 908, L31.

7. **Orr, M.**, Hayward, C. C., Medling, A. M., et al. (2020). Swirls of FIRE: Spatially Resolved Gas Velocity Dispersions and Star Formation Rates in FIRE-2 Disk Environments, *MNRAS* 496, 1620.
8. **Orr, M.**, Hayward, C. C., & Hopkins, P. F. (2019). A Simple Non-equilibrium Feedback Model for Galaxy-Scale Star Formation: Delayed Feedback and SFR Scatter, *MNRAS* 486, 4724.
9. **Orr, M.**, Hayward, C. C., Hopkins, P. F., et al. (2018). What FIREs Up Star Formation: the Emergence of the Kennicutt-Schmidt Law from Feedback, *MNRAS* 478, 3653.
10. **Orr, M.**, Hayward, C. C., Nelson, E. J., et al. (2017). Stacked Star Formation Rate Profiles of Bursty Galaxies Exhibit “Coherent” Star Formation, *ApJL* 849, L2.
11. **Orr, M.**, Pineda, J., & Goldsmith, P. (2014). Photon-Dominated Region Modeling of the [C I], [C II], and CO line emission from a boundary in the Taurus Molecular Cloud. *ApJ* 795, 26.

Contributing Author Publications.....

12. Graf, R. F., Wetzel, A., Bailin, J., & **Orr, M.** (2024). Inside-out versus Upside-down: The Origin and Evolution of Metallicity Radial Gradients in FIRE Simulations of Milky Way-mass Galaxies and the Essential Role of Gas Mixing, *arXiv:2410.21377*.
13. Koudmani, S., Rennehan D., ... **Orr, M.**, et al. (2024). Diverse dark matter profiles in FIRE’s dwarfs: black holes, cosmic rays and the cusp-core enigma, *arXiv:2409.02172*.
14. Steinwandel, U. P., Rennehan D., **Orr, M.**, et al. (2024). Pumping Iron: How turbulent metal diffusion impacts galactic outflows, *arXiv:2407.14599*.
15. ††Porter, L., **Orr, M.**, Burkhardt, B., et al. (2024). Any Way the Wind Blows: Quantifying Superbubbles and their Outflows in Simulated Galaxies across $z \approx 0 - 3$, *arxiv:2406.03535*.
16. Hopkins, P. F., Gurvich, A. B., Shen, X., ... **Orr, M.**, et al. (2023). What causes the formation of discs and end of bursty star formation?, *MNRAS* 525, 2241.
17. Hopkins, P. F., Wetzel, A., Wheeler, C., ... **Orr, M.**, et al. (2023). FIRE-3: Updated Stellar Evolution Models, Yields, & Microphysics and Fitting Functions for Applications in Galaxy Simulations, *MNRAS* 519, 3154.
18. ††Porter, L., **Orr, M.**, Burkhardt, B., et al. (2022). Spatially Resolved Gas-phase Metallicity in FIRE-2 Dwarfs: Late-Time Evolution of Metallicity Relations in Simulations with Feedback and Mergers, *MNRAS* 515, 3555.
19. Kim, J., Golwala, S., Bartlett, J. G., ... **Orr, M.** (2021). Probing Hot Gas Components of Circumgalactic Medium in Cosmological Simulations with the Thermal Sunyaev-Zel’dovich Effect, *ApJ* 926, 179.
20. Su, K.-Y., Hopkins, P. F., Bryan, G. L., ... **Orr, M.**, et al. (2021). Which AGN Jets Quench Star Formation in Massive Galaxies?, *MNRAS* 507, 175.
21. Gurvich, A. B., Faucher-Giguère, C.-A., Richings, A. J., ... **Orr, M.**, et al. (2020). Pressure balance in the multiphase ISM of cosmologically simulated disc galaxies, *MNRAS* 498, 3664.
22. Keating, L., Richings, A., Murray, N., ... **Orr, M.**, et al. (2020). Reproducing the CO-to-H₂ conversion factor in cosmological simulations of Milky Way-mass galaxies, *MNRAS* 499, 837.
23. Benincasa, S. M., Loebman, S. R., ... **Orr, M.**, et al. (2019). Live Fast, Die Young: GMC lifetimes in the FIRE cosmological simulations of Milky Way-mass galaxies, *MNRAS* 497, 3993.
24. Hani, M. H., Hayward, C. C., **Orr, M.**, et al. (2019). Variations in the slope of the resolved star-forming main sequence: a tool for constraining the mass of star-forming regions, *MNRAS* 493, L87.
25. Su, K.-Y., Hopkins, P. F., Hayward, C. C., ... **Orr, M.**, et al. (2019). The failure of stellar feedback, magnetic fields, conduction, and morphological quenching in maintaining red galaxies, *MNRAS* 487, 4393.
26. Su, K.-Y., Hopkins, P., Hayward, C., ... **Orr, M.**, et al. (2018). Cosmic Rays or Turbulence can Suppress Cooling Flows (Where Thermal Heating or Momentum Injection Fail), *MNRAS* 491, 1190.
27. Su, K.-Y., Hopkins, P., Hayward, C., ... **Orr, M.**, et al. (2018). Discrete effects in stellar feedback: Individual Supernovae, Hypernovae, and IMF Sampling in Dwarf Galaxies, *MNRAS* 480, 1666.

28. Hopkins, P. F., Wetzel, A., Kereš, D., ... **Orr, M.**, et al. (2018). FIRE-2 simulations: physics versus numerics in galaxy formation, MNRAS 480, 800.
29. Stark, D. V., Bundy, K.A., **Orr, M.**, et al. (2017). SDSS-IV MaNGA: Constraints on the Conditions for Star Formation in Galaxy Discs, MNRAS 474, 2323.

†† Direct supervision of student project/major involvement as supervisor

Invited Talks.....

University of Memphis Physics Colloquium – Memphis, TN	October 2024
Canadian Institute for Theoretical Astrophysics Seminar – Toronto, ON, Canada	April 2023
Harvard Institute for Theory and Computation Luncheon – Cambridge, MA	March 2023
UC Irvine Disk Settling Workshop – Irvine, CA	September 2022
Maryland Astronomy Center for Theory and Computation Seminar – College Park, MD	September 2022
Santa Cruz Galaxy Workshop – Santa Cruz, CA	August 2022
Princeton University GalRead Seminar – Princeton, NJ	March 2022
<i>Invited Review</i> : NANOGrav Spring 2022 Collaboration Meeting – New York, NY	March 2022
University of Southern California Astro Seminar – Los Angeles, CA	January 2022
FIRE Collaboration Virtual Seminar Series – Virtual	December 2021
Rutgers University Astro Seminar – Piscataway, NJ	October 2020
AAS 2020 Summer Meeting (ISM-BIG Meeting-in-a-meeting) – "Madison, WI"	June 2020
UConn Galaxies Seminar – Storrs, CT	January 2020
UC Santa Cruz IMPS Seminar – Santa Cruz, CA	February 2019
Ohio State University CCAPP Colloquium – Columbus, OH	October 2018

Contributed Talks & Workshops.....

Galaxies Discussion Group Seminar – Cambridge, United Kingdom	September 2024
Localization of fast radio bursts in Taiwan 2024 – Yilan City, Taiwan	June 2024
The ISM of Galaxies & AGN since Cosmic Dawn – Agios Nikolaos, Greece	June 2024
Building Galaxies from Scratch: Simulating Galaxy Evolution – Vienna, Austria	February 2024
Harvard–Heidelberg Star Formation Workshop – Cambridge, MA	October 2023
Revealing the Detailed Astrophysics of Early Galaxies with JWST – Aspen, CO	August 2023
New Views on Feedback & the Baryon Cycle in Galaxies – Healesville, Victoria, Australia	July 2023
Northeast Star & Planet Formation Meeting – Cambridge, MA	June 2023
Olympian Symposium: Star Formation in the Era of JWST – Peralia, Greece	May 2023
Wide-field Spectroscopy vs. Galaxy Formation Theory – Biosphere2, Tucson, AZ	March 2023
Gothamfest 2023 – New York, NY	January 2023
A Holistic View of Stellar Feedback and Galaxy Evolution – Ascona, Switzerland	July 2022
From Stars to Galaxies II – Gothenburg, Sweden	June 2022
AAS 2022 Summer Meeting – Pasadena, CA	June 2022
Our Galactic Ecosystem: Opportunities in the IR and Beyond – Arrowhead, CA	February 2022
VICO-CICO Fall 2021 Workshop – Charlottesville, VA	December 2021
APS Mid-Atlantic Section Regional Meeting – Piscataway, NJ	December 2021
CICO-VICO Fall 2020 Workshop – Virtual	December 2020
New England Star Formation Workshop – Storrs, CT	January 2020
AAS 2020 Winter Meeting – Honolulu, HI	January 2020
Galaxy Formation & Evolution in Southern California 2019 – Irvine, CA	August 2019
AAS 2019 Winter Meeting (Dissertation Talk) – Seattle, WA	January 2019
Galaxy Formation & Evolution in Southern California 2018 – Pasadena, CA	August 2018
Santa Cruz Galaxy Workshop – Santa Cruz, CA	August 2018
The Multi-scale Physics of Star Formation and Feedback – Heidelberg, Germany	June 2018
AAS 2018 Summer Meeting – Denver, CO	June 2018

Swinburne-CalTech Science Workshop 3 (SCTW3) – Pasadena, CA	September 2017
Galaxy Formation & Evolution in Southern California 2017 – Pasadena, CA	August 2017
Star Formation in Different Environments 2017 (SFDE17) – Quy Nhon, Binh Dinh, Vietnam	August 2017
The Local Truth: Star-Formation and Feedback in the SOFIA Era – Asilomar, CA	October 2016
Galaxy Formation & Evolution in Southern California 2016 – Pasadena, CA	September 2016
Theoretical Astrophysics in Southern California 2015 (TASC2015) – Fullerton, CA	November 2015

Public Talks.....

Rutgers Astronomical Society Public Lecture Series – Piscataway, NJ	February 2023
AAI Lecture at William Miller Sperry Observatory (Union County College) – Cranford, NJ	March 2022
Rutgers Astronomical Society Public Lecture Series – Piscataway, NJ	October 2021
Rutgers Astronomical Society Public Lecture Series – Virtual	April 2021
Pasadena Astro on Tap (Caltech Astronomy Outreach) – Pasadena, CA	April 2020
GCC Planetarium “A Conversation with the Stars” – Glendale, CA	April 2019
Caltech Astronomy Outreach Lecture Series – Pasadena, CA	February 2018
Palomar Observatory Greenway Lecture Series – Palomar, CA	November 2017

Student Mentoring

Diane Salim , Ph.D. student, NASA FINESST & Quad Fellow	Rutgers University
Lori Porter , 2021/2022 summer researcher, Goldwater Scholar, AAS 2022 Chambliss Award	University of Louisville, Columbia University

Grant Funding

Co-I (PI: Jorge Pineda): NASA-JPL Strategic Initiative for R&D – \$552,000	FY 2018/2019
<i>Bridging the Gap: Observations and Theory of Star Formation Meet on Large and Small Scales</i>	

Awards, Fellowships & Scholarships

2019: Caltech Institute Service Award	2019: Caltech Institute Leadership Award
2018: TAPIR Oscil Basci Award	2017: Caltech Student Leadership Award
2014: NSF Graduate Research Fellowship	2014: Hertz Fellowship Finalist
2014: Rose Hills Graduate Research Fellowship	2012: Barry M. Goldwater Scholarship