OSASE OMORUYI

Carnegie-Princeton & Flatiron CCA Postdoctoral Fellow, Princeton University
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Education

Ph.D., Harvard University in Astronomy and Astrophysics 2020-25
Thesis: The Multiphase and Multiscale Impact of Stellar and AGN Feedback on Galaxy Evolution
Committee: Grant Tremblay (Advisor), Karin Öberg, Peter Galison, Lars Hernquist, Douglas Finkbeiner

M.A., Harvard University in History of Science 2020-23
Thesis: Reclaiming Space: The Labor Behind International Astronomy in South Africa
Advisors: Prof. Peter Galison and Prof. Chakanetsa Mavhunga

B.S., Yale University in Astronomy and Astrophysics 2015-19
Thesis: A Multiwavelength View of Bubbles in the Milky Way
Advisor: Prof. Héctor Arce

Research Interests and Experience

3 first-author papers published and/or under review. See list of publications below and click here for an exhaustive ADS library.

- Aims to assemble the high-resolution, multi-wavelength observations needed to **calibrate the *ad-hoc* treatment of AGN feedback in cosmological simulations** using **direct observations of feedback** in addition to aggregate galaxy properties

- Specializes in high-resolution, multi-wavelength **X-ray, optical, mm, and radio observations** of **stellar and AGN feedback in galaxies and galaxy clusters**, utilizing telescopes such as JWST, ALMA, *Chandra*, LOFAR, and HST

- Proficient in **computational astrophysics**, particularly in bridging the detailed physical outputs from **hydrodynamical simulations** with computationally inexpensive, flexible **semi-analytic models** of galaxy formation and evolution.

- Experience **conducting ethnographic and archival research** on the **history of astronomy**, examining the roles of race, colonialism, and labor in the development of astronomical observatories in the Global South

- Extensive experience **teaching**, **mentoring** and **organizing workshops** for undergraduate and high school students, with a focus on **supporting marginalized students in STEM**

Honors & Awards

Harvard Frank Knox Memorial Traveling Fellowship (declined) 2025
US Fulbright Research Award Semi-Finalist 2025
Harvard Philippe Wamba Summer Research Travel Grant ($\$5,000$) 2024
ALMA Student Observing Support Grant ($\$40,000$) 2023
Derek Bok Distinction in Teaching Certificate (Harvard University) 2023
John C. Hansen & Katherine Vogelheim Research and Travel Fund for Africa ($\$2,000$) 2022
240th AAS Chambliss Honorable Mention 2022
Harvard Graduate Prize Fellowship 2020
National Science Foundation Graduate Research Fellowship 2019
Yale Astronomy George Beckwith Prize ($\$1,000$) 2019
Yale College Mellon Mays & Edward Bouchet Undergraduate Research Fellowship 2017 - 2019
NSF REU Fellowships at Yale University, Caltech LIGO, and Harvard SAO 2016, 2017, 2018

Observing Time Awarded

Atacama Large Millimeter/submillimeter Array *PI, 29.5 hours*
Cycle 9 PID-2023.1.00471.S: A Comprehensive Observational Test of Positive and Negative Black Hole Feedback

Upgraded Giant Metrewave Radio Telescope *PI, 6 hours*
Cycle 46 PID-084: A Multi-Frequency uGMRT Survey of an Extreme AGN Outburst Tied to Young Star Formation

MMT Observatory *PI, 4 hours*
2023A: Resolving the Cooling Flow Problem in SDSS 1531 with a Spectroscopic Survey

JWST *co-I, 8.6 hours*
Cycle 2 PID-4094: A Galaxy-Scale Fountain of Multiphase Gas Pumped by a Black Hole: The power of JWST combined with ALMA, MUSE, Chandra, and HST

***Chandra* X-ray Observatory**
Cycle 26 PID-26700422: Chandra confirmation of a runaway supermassive black hole *Co-I, 300 ks*
Cycle 26 PID-26700420: A hot shell bounding a multiphase, jet-driven outflow in a nearby galaxy *Co-I, 200 ks*

Talks and Presentations

Wellesley Astronomy Colloquium, *Invited Speaker* — Nov. 2024
AAS Journal Author Series, *Invited Speaker* — Jun. 2024
SAO Harvard Summer Astronomy Colloquium, *Invited Speaker* — Jun. 2024
Space Telescope Spring Symposium on Star Formation, *Contributed Poster and Flash Talk* — Apr. 2024
Tufts Astronomy Seminar, *Invited Speaker* — Mar. 2024
Stockholm University Workshop on Space Science and Care, *Invited Speaker* — Sep. 2023
National Society of Black Physicists Conference, *Contributed Talk* — Nov. 2022
Historic Observatory Networks Conference, *Invited Speaker* — Jun. 2022

Teaching Experience

ASTRON 1: The Big Questions of Astronomy, *Teaching Fellow*, Harvard College — Jan. – May. 2023

Select Review from Median 5.0/5.0 Student Evaluation Rating: *"Osase was an amazing TF! One experience that really stands out to me is during one lab, we were observing the Big Dipper [...] Osase went out of her way to help me identify the Big Dipper, using a variety of methods until I was able to see it. I was so impressed by her determination [...] She was also really great at explaining concepts in the class, and helping students arrive at answers to the homework questions without just giving them answers [...] She was also [...] a warm and friendly and approachable TF in general"*

ASTRON 35S: Fundamentals of Astronomy, *Teaching Fellow*, Harvard Summer School — Jun. – Aug. 2020

Select Review from Median 5.0/5.0 Student Evaluation Rating: *"Osase always made sure every student in the course understood the course's subjects. She was always both patient and informative, pushing others to do their best."*

EVOLUTIONS After School Program, *Teaching Assistant*, Yale Peabody Museum — 2016 - 2019

Select article on work with students: 'Ladies First' exhibit at Peabody spotlights women in STEM

Service & Collaborations

Flatiron CCA AGN & Energy Flows Workshop, *Science Organizing Committee Member* — 2024-Present
Close AGN Reference Survey (CARS), *Member* — 2020-Present
The JWST BCG Collaboration, *Member* — 2025-Present
NSF SAO Astronomy REU Program, *REU Director* — 2023-24
Harvard Astronomy Student-Faculty Council, *Student Representative* — 2022-24
Center for Astrophysics | Harvard & Smithsonian Executive Committee, *Student Representative* — 2023-24
Black Hole Initiative Responsible Siting Group, *Member* — 2023-24
ALMA Distributed TAC, *Proposal Reviewer* — 2022-24
Space Studies Board, National Academies, *Lloyd v. Berkner Space Policy Intern for Astro2020* — 2019-20
Women's Global Education Initiative in Agadir, Morocco, *Participant* — Summer 2019
Girls' Science Investigations at Yale University, *Organizer and Volunteer* — 2018
ACCESS Educational Services "She Looks Just Like Me!" Conference in Bridgeport, CT, *Organizer and Volunteer* — 2018

Science Communication & Outreach

Astrophoto Challenge of Interacting Galaxies, *Invited Subject Matter Expert*, NASA — Nov. 2024
Annual Women+ of Color Project Graduate Applications Workshop, *Lead Organizer & Panelist*, Harvard Univ. — 2020-23
Intro to Astronomy Research Workshop, *Invited Speaker*, EVOLUTIONS After School Program — Jan. 23
Optimizing Code, Python Workshop, *Instructor*, SAO Latino Initiative Program — Aug. 22
Getting Great Letters of Recommendation, *Printed Interview*, GradSchoolShopper Magazine — Aug. 22

Research Press

Black Hole Fashions Stellar Beads on a String — NASA & *Chandra* X-Ray Observatory
200 Millionth Anniversary Gift: A Necklace Made of Stars — AAS NOVA
Cosmic 'necklace' of stars may have formed after powerful black hole outburst — The Independent
Powerful Jets From a Black Hole are Spawning Star Clusters — Universe Today

References

Grant Tremblay, Center for Astrophysics | Harvard & Smithsonian — *Graduate Astronomy Thesis Advisor*

grant.tremblay@cfa.harvard.edu

Rachel Somerville, Flatiron Center for Computational Astrophysics — *Graduate Research Advisor*
rsomerville@flatironinstitute.org

Matthew Ashby, Center for Astrophysics | Harvard & Smithsonian — *Graduate Research & Outreach Collaborator*
mashby@cfa.harvard.edu

Peter Galison, Harvard University — *Graduate History of Science Thesis Advisor*
galison@fas.harvard.edu

Chakanetsa Mavhunga, Massachussetts Institute of Technology — *Graduate History of Science Thesis Co-Advisor*
mavhunga@mit.edu

Héctor Arce, Yale University — *Undergraduate Astronomy Thesis Advisor*
hector.arce@yale.edu

Publication List

FIRST AUTHOR PUBLICATIONS

1. **Omoruyi, O.**, Tremblay, G. R., Combes, F., Davis, T. A., Gladders, M. D., Vikhlinin, A., Nulsen, P., Kharb, P., Baum, S. A., O'Dea, C. P., Sharon, K., Terrazas, B. A., Nevin, R., Schechter, A. L., Zuhone, J. A., McDonald, M., Dahle, H., Bayliss, M. B., Connor, T., Florian, M., Rigby, J. R., and Vaddi, S. (**2024**). **"Beads-on-a-string" Star Formation Tied to One of the Most Powerful Active Galactic Nucleus Outbursts Observed in a Cool-core Galaxy Cluster.** *The Astrophysical Journal*, 963, 1. doi:10.3847/1538-4357/ad1101

> *Summary*: Using high-resolution multi-wavelength data from Chandra, HST, ALMA, and LOFAR, we discovered a chain of 19 young stellar "beads" spatially connected to a giant X-ray cavity in an intermediate-redshift cool core galaxy cluster. We argue that this pattern of star formation likely arose from the combined effects of gas cooling in the turbulent cluster core, an unusually old, large, and powerful AGN outburst displacing the cold gas, and tidal interactions from the merging central galaxies. Together, these results highlight how feedback, cooling, and galaxy mergers can interact in incredibly complex ways, offering a window into the chaotic processes that shaped galaxies and clusters in the early Universe.

2. **Omoruyi, O.**, Tremblay, G., Vikhlinin, A., Dabhade, P., Raychaudhury, S., Markevitch, M., Zuhone, J., Nulsen, P., Baum, S. A., O'Dea, C. P., Clarke, T., Randall, S., Kharb, P., Gulati, S., and Vaddi, S. **A 600 ks Chandra View of Abell 2597.** *Recently accepted to ApJ, expected on arXiv November **2025**, PDF available at doi:10.3847/1538-4357/ae2006*

> *Summary*: Using deep ∼600 ks *Chandra* observations together with archival GMRT radio and SINFONI near-infrared data, we mapped the impact of recurrent AGN outbursts on the cool core of Abell 2597, revealing seven X-ray cavities, weak shocks extending to ∼150 kpc, and a narrow 57 kpc surface brightness deficit likely shaped by sloshing-driven magnetic field amplification. We show that although the AGN injects energy at a level comparable to the cluster's cooling luminosity, radiative cooling still proceeds at ∼15 $M_\odot$ yr^{-1}, fueling a billion-solar-mass cold gas reservoir that cannot be sustained by Bondi accretion alone. Together, these results provide strong observational support for chaotic cold accretion as the dominant fueling mode in Abell 2597, offering a detailed view of how cooling, feedback, and gas dynamics cooperate to regulate the cores of cool core clusters.

3. **Omoruyi, O.**, Terrazas, B., Gabrielpillai, A., Oren, Y., Pandya, V., Somerville, R., and Hernquist, L. **Emulating IllustrisTNG with a semi-analytic model.** *Submitted to MNRAS, expected on arXiv January **2026a**, PDF available at https://osaseo.github.io/publications/*

> *Summary:* By combining the strengths of the Santa Cruz semi-analytic model and the IllustrisTNG100 hydrodynamical simulation, we developed the TNG SAM—a fast, flexible model calibrated to match the flow of gas and metals in stellar-feedback–dominated TNG galaxies. We show that a set of physically motivated updates to cooling, star formation, recycling, outflows, and gas re-accretion allows the SAM to reproduce TNG's baryon cycle and its global galaxy and halo properties to within ∼30% out to $z = 6$. Together, these results demonstrate that semi-analytic models, when properly calibrated, can capture much of the complex physics of hydrodynamical simulations, providing an efficient and physically grounded tool for studying galaxy evolution across cosmological volumes.

4. **Omoruyi, O.**, Tremblay, G., Ashby, M., Baum, S., Blanton, E., Bremer, M., Bulbul, G., Clarke, T., Combes, F., Connor, T., David, L., Davis, T., Donahue, M., Edge, A., Edwards, L., Fabian, A., Forman, W., Gaspari, M., Grace, S., Greene, J., Hamer, S., Jones, C., Kraft, R., Li, Y., McDonald, M., McNamara, B., Nevin, R., Nulsen, P., O'Dea, C., Ogle, P., Oonk, R., Powell, M., Randall, Reefe, M., S., Russell, H., Salome, P., Schechter, A., Simionescu, A., Starikova, S., Su, Y., Sun, M., Terrazas, B., Urry, C., Vantyghem, A., Vikhlinin, A., Voit, M., Wilkes, B., Worku, K., and ZuHone, J. **A JWST MIRI and NIRSpec View of the Heart of Abell 2597.** *In preparation. Expected on arXiv February **2026b**.*

> *Summary*: Using new JWST MIRI and NIRSpec IFU observations of the core of Abell 2597, we present mid-infrared and near-infrared spectra that reveal numerous emission lines tracing warm molecular gas, ionized gas, and dust, including several features consistent with shock excitation.

CONTRIBUTING AUTHOR PUBLICATIONS

1. Oren, Yossi, Viraj Pandya, Rachel S. Somerville, Shy Genel, **Osase Omoruyi**, and Amiel Sternberg. **The Cosmic Baryon Cycle in IllustrisTNG: Flows of Mass, Energy, and Metals**. (**2025, arXiv**) *Submitted to Monthly Notices of the Royal Astronomical Society.* doi:arXiv.2510.23343.

> *Summary & Contribution:* Using the IllustrisTNG100 simulation, we measured the flows of mass, metals, and energy through the ISM and CGM to trace how galaxies exchange material with their environments across cosmic time. We find that early galaxies experience strong inflows, while the onset of kinetic AGN feedback in massive halos later brings inflows and outflows into balance and drives quenching, offering a clear picture of how different feedback channels regulate galaxy growth in TNG. I performed detailed cross-checks to ensure the physical soundness of the galaxy sample and tested the resulting flow catalogs for their utility in the Santa Cruz semi-analytic model, directly shaping the calibration of the TNG SAM in Omoruyi+26a.

2. Singha, M., Scharwächter, J., Kakkad, D., **Omoruyi, O.**, Rojas, A., Laha, S., Pérez-Torres, M., Combes, F., Sadaula, D. R., Baum, S. A., O'Dea, C. P., Tremblay, G. R., Sebastian, B. **A quenched galaxy at the site of supermassive black hole feedback**. *Submitted to ApJ, expected on arXiv early-December 2025, PDF available at https://osaseo.github.io/publications/*

> *Summary & Contribution:* Using optical IFU and millimeter observations, we identified a galaxy in which AGN-driven ionized outflows have depleted the central reservoir of cold molecular gas. The data suggest that the outflows directly suppressed star formation by removing or destroying the gas needed to form new stars, providing a clear example of AGN-driven quenching. I reduced and analyzed the archival ALMA data, revealing the distinct depletion of molecular gas along the outflow's path and strengthening the interpretation of AGN-regulated quenching.

3. Dunn, Thomas, Rebecca McElroy, Mirko Krumpe, Croom, Scott M., Gaspari, Massimo, Perez-Torres, Miguel, Cowley, Michael, **Omoruyi, Osase**, Tremblay, Grant, Singha, Mainak. **A Century of Change: New Changing-Look Event in Mrk 1018's Past**. (**2025, arXiv**). *Submitted to Publications of the Astronomical Society of Australia.* doi:arXiv.2510.25156.

> *Summary & Contribution:* Using over a century of archival photographic plates and modern survey data, we uncovered a previously unknown bright phase of the changing-look AGN Mrk 1018 in the mid-20th century. We show that its decades-long variability pattern is consistent with stochastic changes in the accretion flow rather than strict periodicity, extending the historical baseline for the behavior of changing-look AGN. I provided detailed comments on the analysis and interpretation.

4. Elford, Jacob S, Timothy A Davis, Ilaria Ruffa, Stefi A Baum, Francoise Combes, Massimo Gaspari, Rebecca McElroy, Christopher P O'Dea, **Osase Omoruyi**, Mainak Singha, Grant R Tremblay, Nico Winkel. (**2025, MNRAS**). **The Close AGN Reference Survey (CARS): A Comparison between Sub-Mm and Optical AGN Diagnostic Diagrams**. *Monthly Notices of the Royal Astronomical Society 541 (2): 1994–2007.* doi:10.1093/mnras/staf1096.

> *Summary & Contribution:* Using ALMA observations of dense-gas tracers in nearby AGN, we compared sub-millimeter diagnostic diagrams against classic optical emission-line classifications. We find broad agreement between the two methods, demonstrating that AGN imprint consistent signatures across both ionized and dense molecular gas phases. I provided detailed feedback to enhance the clarity of the observational data presentation and the physical picture emerging from the data.

5. Ogle, P. M., Sebastian, B., Aravindan, A., McDonald, M., Canalizo, G., Perley, R. A., Ashby, M., Azadi, M., Antonucci, R., Barthel, P., Baum, S., Birkinshaw, M., Carilli, C., Chiaberge, M., Duggal, C., Gebhardt, K., Hyman, S., Kuraszkiewicz, J., Lopez-Rodriguez, E., Medling, A., Miley, G., **Omoruyi, O.**, O'Dea, C., Perlman, E., Reynaldi, V., Singha, M., Sparks, W., Tremblay, G., Wilkes, B., Willner, S., and Worrall, D. **The JWST View of Cygnus A: Jet-Driven Outflow with a Twist**. (**2025**, ApJ). *The Astrophysical Journal 983 (2): 98.* doi:10.3847/1538-4357/adb71a.

> *Summary & Contribution:* Using JWST NIRSpec and MIRI spectroscopy combined with KCWI data, we mapped a rotating, multi-phase outflow in Cygnus A that is strongly shaped by the radio jet. We find a biconical, spiral-like flow pattern with dense, high-velocity clumps approaching 2000 km s^{-1}, revealing the detailed structure of jet–ISM coupling in a powerful nearby radio galaxy. I provided feedback on the presentation and interpretation of the observational data.

6. Singha, M., Winkel, N., Vaddi, S., Perez Torres, M., Gaspari, M., Smirnova-Pinchukova, I., O'Dea, C. P., Combes, F., **Omoruyi, O.**, Rose, T., McElroy, R., Husemann, B., Davis, T. A., Baum, S. A., Lawlor-Forsyth, C., Neumann, J., Tremblay, G. R.. (2023, ApJ). **The Close AGN Reference Survey (CARS): An interplay between radio jets and AGN radiation in the radio-quiet AGN HE 0040-1105**. *The Astrophysical Journal*, 959(2), 107. doi:10.3847/1538-4357/ad004d

> *Summary & Contribution:* Combining VLT/MUSE, HST, VLA, and VLBI observations, we identified multiple components of ionized gas in the radio-quiet AGN HE 0040–1105, including a compact outflow likely powered by a weak jet. We find that the outflow velocities are too low to escape and may cycle back into the galaxy, pointing to a self-regulating feedback loop in the nucleus. I reduced the HST NUV data and identified clumpy nuclear gas, providing key evidence that the system is a late-stage merger remnant.

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