Sarah Jeffreson

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Employment

2024–pres. **Postdoctoral Associate**, *Princeton University,* Princeton NJ, United States

- Analyzed the largest suite of high-resolution, massively-parallel isolated galaxy simulations to date *(Python, scipy, numpy),* fitting a pressure-regulated sub-grid model approach, and producing one peer-reviewed research paper
- Leading the development and implementation of the new sub-grid model *(C with MPI, over 5,000 lines of code)*
- Building an ML-based emulator to replace sub-grid models in future simulations *(PyTorch, neural networks)*
- Publications and ongoing work contributed directly to the successful renewal of the Learning the Universe Simons Collaboration for the period 2025-27, valued at ~ 6M

2024–pres. **Visiting scholar**, *Harvard University,* Cambridge MA, United States

2020–2024 **Institute for Theory and Computation Fellow, Harvard-Smithsonian Center for Astrophysics**, *Harvard University,* Cambridge MA, United States

- Developed and ran the largest suite of high-resolution isolated galaxy simulations to date (>100,000 CPU hours) [peer-reviewed research paper]
- Built a new, efficient model for these simulations — the momentum injected by stellar clusters within hydrodynamical galaxy simulations, based on a customized FoF clustering algorithm *(massively-parallel simulations — C with MPI)* [peer-reviewed research paper]
- Using these simulations (>1 TB of data), developed a pipeline to extract trends in gas accretion/expulsion from samples of 10,000 star-forming molecular clouds and >1M gas tracer particles *(data handling/analysis — Python, scipy, numpy, pandas)* [peer-reviewed research paper]
- Discovered that large star-forming clouds are sustained by gas accretion, resolving a long-standing conflict in star formation theory
- In total, this work has so far led to six first-author peer-reviewed research papers, with >110 citations

Education

2016–2020 **Ph.D. in Astrophysics (Magna Cum Laude)**, *International Max Planck Research School for Astrophysics,* University of Heidelberg, Germany

- Developed and ran three massively-parallel hydrodynamical simulations of galaxies *(C with MPI, up to 1000 threads)*
- Cleaned and analyzed simulation datasets (>1TB) to uncover novel, statistically-significant trends in star-forming cloud properties *(Python, SciPy, linear least-squares optimization, confidence testing)* [peer-reviewed research paper]
- Developed a pipeline to extract the lifetimes of 100,000 star-forming molecular clouds from >1000 time-stepped images of the simulated galaxies, as a collection of unique paths from a directed acyclic graph *(NetworkX, MC Tree Search)* [GitHub] [peer-reviewed research paper]
- This work resulted in three first-author publications, >190 citations, and a highly-competitive research fellowship at Harvard ($360,000, 1% success rate)

2015–2016 **MSc Physics/Astrophysics (1st class honors)**, *University of Cambridge*

- Determined the Bayesian evidence for rotation among observations of stellar clusters (parametric models, Bayesian fitting, MCMC sampling) [peer-reviewed research paper].
- Final exams in Quantum Field Theory, Cosmology, Particle Physics and Galactic Dynamics.

2012–2015 **BA Hons Physics (2.I)**, *University of Cambridge*

Grants, awards and funding

2023 **Scholarly Studies Grant ($10,635)**, *Smithsonian Astrophysical Observatory,* to support an undergraduate student working on the research program entitled 'The influence of superbubble feedback on molecular gas and star formation across galactic environments'

2020 **Institute for Theory and Computation Fellowship ($360,000)**, *Harvard University,* Independent research fellowship (success rate of 1%)

2017 **NEON Observing School scholarship (EUR 3500)**, *University of Copenhagen and La Palma Observatory* (success rate 22%)

2014 **Research in Industrial Projects for Students scholarship ($10,000)**, *Institute of Pure and Applied Mathematics, UCLA* (success rate 7%)

2013-2016 **Scholarship for continued academic excellence, Gonville and Caius College**, *Cambridge University*

2013 **Amgen Scholars Programme scholarship ($9,000)**, *Karolinska Institutet* (success rate 7%)

Selected publications

A full submitted/refereed publication list can be found on Google Scholar

2017–pres. 13 first-author/mentored student (*), 27 total, **H-index = 15, citations 980**

*Jeffreson, S. M. R., **Ostriker, E. C., Kim, C. et al.** Learning the Universe: Pressure-regulated feedback-modulated star formation as a sub-grid model in the moving-mesh code Arepo *to be submitted (2025)*

*Jeffreson, S. M. R., **Ostriker, E. C., Kim, C. et al.** Learning the Universe: GalactISM simulations of resolved star formation and galactic outflows across main sequence and quenched galactic environments ***ApJ, 975**, 113* (2024)

***Angress, A., Foley, M.,** Jeffreson, S. M. R., **et al.** Unmasking Stellar Feedback-Driven Bubbles: Identification and Properties Analysis *submitted (2025)*

***Carriera, Courtney, Koch, E. W.,** Jeffreson, S. M. R. **et al.** How do spiral arms influence molecular cloud and star formation? Comparing multiple ISM tracers across M33's spiral arm to simulations, *to be submitted* (2024)

*Jeffreson, S. M. R., **Semenov, V. A., Krumholz, M. R.,** Clouds of Theseus: long-lived molecular clouds are composed of short-lived H2 molecules, ***MNRAS, 527**, 7093* (2024)

Watkins, E. J., Barnes, A. T. et al. (incl. Jeffreson, S. M. R.), PHANGS-JWST First Results: A Statistical View on Bubble Evolution in NGC 628, ***ApJ, 944,** 24* (2023)

***Skarbinski, M.,** Jeffreson, S. M. R., **Goodman, A. A.,** Building the molecular cloud population: the role of cloud mergers, ***MNRAS, 519,** 1887* (2022)

*Jeffreson, S. M. R., **Sun, J., Wilson, C. D.,** On the scale-height of the molecular gas disc in Milky Way-like galaxies, ***MNRAS, 515**, 1663* (2022)

Reina-Campos, M., Keller, B. W., Kruijssen, J. M. D., et al. (incl. Jeffreson, S. M. R.) Introducing EMP-Pathfinder: modelling the simultaneous formation and evolution of stellar clusters in their host galaxies, ***MNRAS, 517**, 3144* (2022)

*Jeffreson, S. M. R., **Krumholz, M. R., Fujimoto, Y. et al.,** Momentum feedback from marginally-resolved HII regions in isolated disc galaxies, ***MNRAS, 505**, 3470* (2021)

*Jeffreson, S. M. R., **Keller, B. W., Winter, A. J. et al.,** A scaling relation for the molecular cloud lifetime in Milky Way-like galaxies, ***MNRAS 505**, 1678* (2021)

*Jeffreson, S. M. R., **Kruijssen, J. M. D., Keller, B. W. et al.,** The role of galactic dynamics in shaping the physical properties of giant molecular clouds in Milky Way-like galaxies, ***MNRAS, 498**, 385* (2020)

Chevance, M. et al. (incl. Jeffreson, S. M. R.), The lifecycle of molecular clouds in nearby star-forming disc galaxies, ***MNRAS, 493****, 2872* (2020)

*Jeffreson, S. M. R., **Kruijssen, J. M. D., Krumholz, M. R. et al.,** On the physical mechanisms governing the cloud lifecycle in the Central Molecular Zone of the Milky Way, ***MNRAS, 478****, 3380* (2018)

*Jeffreson, S. M. R., **Kruijssen, J. M. D.,** A general theory for the lifetimes of giant molecular clouds under the influence of galactic dynamics, ***MNRAS, 476****, 3688* (2018)

*Jeffreson, S. M. R., **Sanders, J. L., Evans, N. W., Williams, A. A., Gilmore, G. F. et al.,** The Gaia-ESO Survey: dynamical models of flattened, rotating globular clusters, ***MNRAS, 469****, 4740* (2017)

Mentoring/advising

2024–pres. **Lori Porter**, *graduate student, Columbia University:* "Star-forming gas in Early-Type galaxies"

2023–pres. **Madisen Johnson**, *graduate student, Rutgers University:* "The rate of molecular gas accretion and collapse across galactic environments"

2023–pres. **Aaron Angress**, *graduate student, CUNY:* "Unmasking Stellar-Feedback Driven Bubbles: Identification and Properties Analysis"

2022–pres. **Courtney Carriera**, *graduate student, UC Santa Cruz:* "How do spiral arms influence molecular cloud and star formation? Comparing multiple ISM tracers across M33's spiral arm to simulations"

2022–2023 **Adriana Medina**, *Junior, UMass Lowell* "Positive feedback: the role of supernovae in driving star formation"

2022–2023 **Gorak Rajesh**, *Sophomore, Cambridge University, UK:* "The role of flocculent spiral arms in triggering molecular cloud formation"

2021–2022 **Maya Skarbinski**, *Junior, Harvard University:* "Building the molecular cloud population: the role of cloud mergers"

Teaching

2019 **Experimental Physics II, class of 20**, *University of Heidelberg,* Electrostatics, Electrodynamics, Electromagnetism, Optics, Special Relativity

2018–2019 **Experimental Physics I, class of 20**, *University of Heidelberg,* Mechanics and Thermodynamics

Selected talks

2017–pres. 16 Invited talks/colloquia/seminars

Jun. 2024 **Invited talk,** *Illustris-TNG Anniversary Conference,* Tuscany, Italy

Jun. 2024 **Invited talk,** *Alpbach workshop on clouds, star clusters & black holes,* Alpbach, Austria (declined)

Apr. 2024 **Invited seminar,** *UC Berkeley TAC Seminar,* Berkeley, USA (declined)

Apr. 2024 **Invited seminar,** *ISM Salon at the Center for Computational Astrophysics,* NYC, USA (declined)

Dec. 2023 **Contributed talk,** *IAP Colloquium: New simulations for new problems in galaxy formation,* Paris, France

Nov. 2023 **Invited colloquium,** *University of Massachusetts,* Amherst, USA

Oct. 2023 **Contributed talk,** *Surveying the Milky Way,* Pasadena, USA

Jul. 2023 **Invited colloquium,** *Argelander Institute for Astronomy,* Bonn, Germany

Jul. 2023 **Invited seminar,** *Cologne University,* Germany

Jun. 2023 **Contributed talk,** *Olympian Symposium: Star formation in the era of JWST,* Paralia Katerini, Greece

May 2023 **Invited colloquium,** *University of Vienna,* Austria

Dec. 2022 **Invited colloquium,** *Königstuhl Colloquium, MPIA,* Heidelberg, Germany

Oct. 2022 **Invited talk,** *ITC Luncheon,* Harvard University, USA

Sep. 2022 **Seminar,** *Galaxy Group Meeting,* CCA, New York City

Aug. 2022 **Contributed talk,** *IAU Symposium 373: Resolving the Rise and Fall of Star formation in Galaxies,* Busan, Korea (online)

Jul. 2022 **Contributed talk,** *A holistic view of stellar feedback,* Ascona, Switzerland

Jun. 2022 **Contributed talk,** *From Stars to Galaxies II - Connecting our understanding of star and galaxy formation,* Gothenburg, Sweden

May 2022 **Invited seminar,** *McMaster University,* Canada

Apr. 2022 **Invited seminar,** *MSS Seminar, University of Wisconsin-Madison,* USA (online)

Jan. 2022 **Invited seminar,** *MPA Seminar,* Munich, Germany (online)

Dec. 2021 **Invited seminar,** *ANU,* Canberra, Australia

Jul. 2021 **Contributed talk,** *Ringberg series,* Germany (online)

May 2021 **Contributed talk,** *ISM 2021: Structure, characteristic scales, and star formation,* Beirut

Oct. 2020 **Invited colloquium,** *ITC Colloquium,* Harvard University, USA (online)

Nov. 2019 **Contributed talk,** *Harvard-Heidelberg workshop on the Physics of Star Formation: Linking Observations and Simulations,* Cambridge, USA

Sep. 2019 **Contributed talk,** *Through Dark Lanes to New Stars, celebrating the career of Prof. Charles Lada,* Crete, Greece

Jun. 2019 **Contributed talk,** *Linking the Milky Way and Nearby Galaxies,* Helsinki, Finland

Nov. 2018 **Contributed talk,** *Hendrik van de Hulst Centennial Symposium: The Interstellar Medium of Galaxies, Status and Future Perspectives,* Leiden, The Netherlands

Jul. 2018 **Contributed talk,** *The Laws of Star Formation: From the Cosmic Dawn to the Present Universe,* Cambridge, UK

Jun. 2018 **Invited talk,** *The Multi-Scale Physics of Star Formation and Feedback during Galaxy Formation,* Heidelberg, Germany

Jun. 2017 **Contributed talk,** *Galactic Star Formation with Surveys,* Heidelberg, Germany

Observing time

2017–pres. **Co-investigator on successful ALMA proposals (>50 hours of awarded observing time)**, *Cycles 5-10,* Principal Investigators Eric Koch, Mélanie Chevance and Alexander Hygate

Scientific leadership and responsibilities held

2021–2024 **ITC Colloquium organizing Committee**, *Harvard University*

2022–2023 **Submillimeter Array (SMA) Time Allocation Committee**, *Smithsonian Astrophysical Observatory*

2020, 21, 23 **ITC Fellowship Selection Committee**, *Harvard University*

2023 **CfA Postdoc Committee**, *Harvard & Smithsonian*

2023 **Conference organizing Committee**, *New England Star Formation Workshop*

2022 **Conference organizing Committee**, *Heidelberg-Harvard Star Formation Workshop,* Max Planck Institute for Astronomy

2022 **Conference Local organizing Committee**, *Seeing the Future: Of the Universe, Data, Learning & Digital Scholarship,* Harvard University

2021 **ITC Luncheon organizing Committee**, *Harvard University*

Outreach

2022 **Public interview: 'Cosmic Cliffs' James Webb image**, *Boston Museum of Science (planetarium and social media)*

2021 **Guest lecturer**, *for Ay98 (Research tutorial in Astrophysics for undergraduates)*

2020–pres. **YouTube channel 'Sarah Jeffreson'**, *short descriptions of some of my papers for a general astronomy audience*

Refereeing

2023–pres. **Referee**, *The Astrophysical Journal*

2019–pres. **Referee**, *Monthly Notices of the Royal Astronomical Society*

Coding and tools

Coding **Python (numpy, pandas, scipy),** *experience with:* scikit-learn, PyTorch

C (with MPI) *experience with:* C++, Fortran, HTML, CSS

Tools **git, LaTeX,** *experience with:* Bash