

Jonathan Fraine

Exoplanets, Data Science, and Artificial Intelligence

Work Experience

- 2018 - **Research Scientist**, *Space Science Institute*, Machine Learning Specialist, Hubble and James Webb Space Telescopes.
- 2017 - 2018 **Research Scientist**, *Space Telescope Science Institute*, Instruments Division, James Webb Space Telescope.
- 2015 - 2017 **Postdoctoral Research Associate**, *University of Arizona*, Steward Observatory, James Webb Space Telescope - Near Infrared Camera (NIRCam).

Education

- 2009 - 2015 **Ph.D. Astronomy**, *University of Maryland*, College Park.
Exoplanet Spectroscopy by Combining HST WFC3 and Magellan IMACS & MMIRS
- 2013 - 2015 **Predoctoral Fellow**, *California Institute of Technology*, Pasadena, CA.
Exoplanet Spectroscopy with HST WFC3
- 2013 - 2015 **Predoctoral Fellow**, *Pontificia Universidad Católica de Chile*, Santiago, Chile.
Exoplanet Spectroscopy with Magellan IMACS
- 2009 - 2011 **M.S. Astronomy**, *University of Maryland*, College Park.
Novel Gravity Solver for Fluid Dynamical Planet Formation Simulations with *ATHENA*
- 2007 - 2009 **M.S. Mathematics**, *University of Central Florida*, Orlando.
Image Analysis and Machine Learning
- 2003 - 2006 **B.S. Physics**, *University of Central Florida*, Orlando, Astronomy Specialization.
Condensed Matter Laboratory Research in Magnetic Nanofluids

Research Interests

Data Science, artificial intelligence, and machine learning.
Remote Sensing for United Nations Sustainable Development Goals.
Exoplanet atmospheres, planet formation, and astrobiology.
Bayesian inference and statistical modeling.
Exploratory data analysis and data mining.
Computational and mathematical modeling.
Time series analysis and signal processing.
Biological systems, biochemistry, and bioinformatics.

Recent Honors & Awards

- 2019 United Nations Panel Member for “Prospects & Ethics of Innovation and Technology in Official Statistics” for Economic and Social Commission of Western Asia

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Funding and Observing Proposals

- 2018 **“WFC3-UVIS Eclipse Observation of WASP-43b: Helping James Webb See Through the Clouds”**,
HUBBLE SPACE TELESCOPE, **PI: Jonathan Fraine.**
Parmentier, V., Lewis, N., Stevenson, K, Wakeford, H, Kataria, T, Kreidberg, L, Bean, J, Todorov, K, Feng, K, Morley, C, Bruno G, Kilpatrick B, Fortney J, Line, M
- 2017 **“Cloudy Solutions to the Anomalous Emission of HD 80606b”**,
HUBBLE SPACE TELESCOPE, **Co-PI: Jonathan Fraine.**
Parmentier, V., Lewis, N., Stevenson, K, Wakeford, H, Kataria, T, Kreidberg, L, Bean, J, Todorov, K, Feng, K, Morley, C, Bruno G, Kilpatrick B, Fortney J, Line, M
- 2017 **“Maximizing JWST GTO Observations of HAT-P-26b with Time-Critical Spitzer Eclipse Measurements”**,
SPITZER SPACE TELESCOPE, **PI: Jonathan Fraine.**
Stevenson, K.B., Wakeford, H.R., Knutson, H., Wallack, N., Goyal, J., Sing, D., Lewis, N., Valenti, J., Batalha, N., Bruno, G., Kilpatrick, B., Greene, T.

Ph.D. Thesis

- Title *Diagnosing Clouds and Hazes in Exoplanetary Atmospheres*
- Advisors Drs. Drake Deming, Andrés Jordán, Heather Knutson, Derek Richardson, J. Patrick Harrington
- Description Using time-domain machine learning techniques with multi-epoch, multi-instrument observations from both space and ground based facilities, I constrained exoplanetary atmospheric compositions over a span of planetary masses. My work using Spitzer-IRAC on GJ 1214b, a transiting Super-Earth exoplanet ($\sim 2.7 R_{\oplus}$), precisely constrained the infrared radius to $\sim 100\text{km}$, significantly constraining the anomalous lack of any molecular detections. My work on HAT-P-11 b was the first detection of a molecular signature from a small exoplanet ($\sim 4.5 R_{\oplus}$); using water vapour as a proxy to infer the presence of a hydrogen rich atmosphere for this exo-Neptune. I was one of the founding members of the ACCESS collaboration, a ground based observational campaign to spectroscopically survey a catalogue of exoplanetary architectures using major optical telescopes.

M.S. Thesis Astrophysics

- Title *Gas Dynamics in Protoplanetary Disks: Cylindrical MHD Simulations with a Novel Gravity Solver*
- Advisors Drs. Eve Ostriker, Derek Richardson, Lee Mundy
- Description I developed a novel gravity solver intrinsically in cylindrical coordinates to implement self-gravity with the 3D fluid dynamics package ATHENA and study self-gravitating fluid dynamics for planet formation. Our results provided critical insights to develop new understanding from cylindrical objects in space: planet forming disks, black hole accretion disks, and galaxies.

Publications

Refereed Journals

- *2019 **“Machine Learning Fast and Efficient Bad Pixel Detection with HxRG Detectors.”**, PASP, in prep.
Fraine, J.D., Misselt, K., Willmer, C., Brooks, B., Rest, A., Fullerton, A., Rieke, M.
- *2019 **“Anomalous *warm* Spitzer phase curve of Qatar-2b at 3.6 and 4.5 μm ”**, APJ, submitted.
Fraine, J.D., Stevenson, K.B., Kataria, T., Munoz C., Kempton, E., Brooks, B., Bean, J., STARGATE Collaboration
- 2019 **“Auto-Parallel Observations with the James Webb Space Telescope”**, PASP, submitted.
Holwerda, B., **Fraine, J.D.**, Mouawad, N., Bridge, J.
- *2018 **“Transiting Exoplanet Characterization Beyond 2030: A Case for Observing Giant Planets with Giant Telescopes”**, NATIONAL ACADEMY OF SCIENCES, Exoplanet Science Strategy.
Fraine, J.D., Wakeford, H.R., Kataria, T., Stevenson, K.B., Meixner, M., Fortney, J., Morley, C.V., Adibekyan, V., Beichman, C., Berta-Thompson, Z., Bruno, G., Dong, C., Danchi, W., Gaidos, E., Gao, P., Greene, T., Kaltenegger, L., Kane, S., Line, M.R., Marley, M., and Pontoppidan, K.
- 2018 **“The Origins Space Telescope: Towards An Understanding of Temperate Planetary Atmospheres”**, NATIONAL ACADEMY OF SCIENCES, Exoplanet Science Strategy.
Fortney, J.; Kataria, T.; Stevenson, K.; Zellem, R.; Nielsen, E.; Cuartas-Restrepo, P.; Gaidos, E.; Bergin, E.; Meixner, M.; Kane, S.; David, L.; **Fraine, J.**; and 37 other authors
- 2018 **“The Transiting Exoplanet Community Early Release Science Program for JWST”**, PASP, Vol 130, N. 993.
Bean, J.L., Stevenson, K.B., Batalha, N.M., Berta-Thompson, Z., Kreidberg, L., Crouzet, N., Benneke, B., Line, M.R., Sing, D.K., Wakeford, H.R., Knutson, H.A., Kempton, E.M., -R., Désert, J.-M., Crossfield, I., Batalha, N.E., de Wit, J., Parmentier, V., Harrington, J., Moses, J.I., Lopez-Morales, M., Alam, M.K., Blecic, J., Bruno, Giovanni; Carter, Aarynn L., Chapman, John W., Decin, Leen; Dragomir, Diana; Evans, Thomas M., Fortney, Jonathan J., **Fraine, Jonathan D.**, and 68 other authors
- 2018 **“Starspot Occultations in Infrared Transit Spectroscopy: The Case of WASP-52b”**, AJ, Vol. 156, Issue 3.
Bruno, G, Lewis, N.K., Stevenson, K.B., Filippazzo, J., Hill, M., **Fraine, J.D.**, Wakeford, H.R., Deming, D., Lopez-Morales, M., Alam, M.K.
- 2018 **“A Comparative Study of WASP-67 b and HAT-P-38 b from WFC3 Data”**, AJ, Vol. 155, Issue 55.
Bruno, G, Lewis, N.K., Stevenson, K.B., Filippazzo, J., Hill, M., **Fraine, J.D.**, Wakeford, H.R., Deming, D., Kilpatrick, B., Line, M.R., Morley, C.V., Collins, K.A., Conti, D.M., Garlitz, J, Rodriguez, J.E.
- 2017 **“Statistical Analysis of Hubble/WFC3 Transit Spectroscopy of Extrasolar Planets”**, APJL, Vol. 847, Issue 22.
Fu, G., Deming, D., Knutson, H., Madhusudhan, N., Mandell, A., **Fraine, J.**

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- 2017 **"Community targets for JWST's early release science program: evaluation of WASP-63b"**, *AJ*, Vol. 156 Issue 3.
Kilpatrick, B.M., Cubillos, P.E., Stevenson, K.B., Lewis, N.K., Wakeford, H., Macdonald, R.J., Madhusudhan, N., Blecic, J.; Bruno, G; Burrows, A; Deming, D; Heng, K., Line, M.R., Morley, C.V., Parmentier, V., Tucker, G.S., Valenti, J.A., Waldmann, I.P., Bean, J.L., Beichman, C., **Fraine, J.D.**; Krick, J.E., Lothringer, J.D., Mandell, A.M.
- 2017 **"ACCESS I: An Optical Transmission Spectrum of GJ 1214b Reveals a Heterogeneous Stellar Photosphere"**, *APJ*, Vol. 834, Issue 2.
Rackham, B., Espinoza, N., Apai, D., López-Morales, M., Jordán, A., Osip, D., Lewis, N., Rodler, F., **Fraine, J.**, Morley, C., Fortney, J.
- 2017 **"Two NIRCcam Channels are Better Than One: How JWST Can Do More Science With NIRCcam's Short-Wavelength Dispersed Hartman Sensor"**, *APJ*, Vol. 129, Issue 971.
Schlawin, E., Rieke, M., Leisenring, J., Walker, L.M., **Fraine, J.**, Kelly, D., Misselt, K., Greene, T., Line, M., Lewis, N., Stansberry, J.
- 2016 **"Transiting Exoplanet Studies and Community Targets for JWST's Early Release Science Program"**, *APJ*, Vol. 128, Issue 967.
Stevenson, K., Lewis, N., Bean, J., Beichman, C., **Fraine, J.**, and 47 other authors
- 2015 **"Spitzer Secondary Eclipses of the Dense, Modestly-irradiated, Giant Exoplanet HAT-P-20b Using Pixel-level Decorrelation"**, *APJ*, Vol. 805, Issue 2.
Deming, D., Knutson, H., Kammer, J., Fulton, B., Ingalls, J., Carey, S., Burrows, A., Fortney, J.J., Todorov, K., Agol, E., Cowan, N., Desert, J.-M., **Fraine, J.**, Langton, J., Morley, C., Showman, A.P.
- *2014 **"Water Vapour Absorption from the Clear Atmosphere of an Exo-Neptune"**, *NATURE*, Vol. 513, Issue 7519, pp. 526-529.
Fraine J.D., Deming, D., Benneke, B., Knutson, H., Jordán, A., Espinoza, N., Madhusudhan, N., Wilkins, A., Todorov, K.
- 2014 **Search for a habitable terrestrial planet transiting the nearby red dwarf GJ 1214**, *A&A*, Vol. 563, id.A21, 13 pp..
Gillon, M., Demory, B.-O., Madhusudhan, N., Deming, D., Seager, S., Zsom, A., Knutson, H. A., Lanotte, A. A., Bonfils, X., Désert, J.-M., Delrez, L., Jehin, E., **Fraine J.D.**, Magain, P., Triaud, A.
- *2013 **"Spitzer Transits of the Super-Earth GJ 1214 b and Implications for Its Atmosphere"**, *APJ*, Vol. 765, Issue 2, article id. 127.
Fraine J.D., Deming D., Gillon M., Jehin E., Demory B.O., Benneke B., Seager S., Lewis N.K., Knutson H., and Désert J.M.
- 2012 **"Infrared Eclipses of the Strongly Irradiated Planet WASP-33b, and Oscillations of Its Host Star"**, *APJ*, Vol. 754, Issue 2, article id. 106.
Deming D, **Fraine J.D.**, Sada P.V., Madhusudhan N., Knutson H.A., Harrington J., Blecic J., Nymeyer S., Smith A.M.S., Jackson B.
- 2012 **"Extrasolar Planet Transits Observed at Kitt Peak National Observatory"**, *PASP*, Vol. 124, Issue 913, pp.212-229.
Sada P.V., Deming D., Jennings D.E., Jackson B.K., Hamilton C.M., **Fraine J.D.**, Peterson S.W., Haase F., Bays K., Lunsford A., O'Gorman E.

Invited Talks

- 2018 "Exoplanets in the Era of JWST"
Third Arab Astronomy Winter School at American University of Beirut
- 2018 "Interactive tutorials on Exoplanet Atmospheric Analysis and Extraction"
Third Arab Astronomy Winter School at American University of Beirut
- 2017 "The Development of Artificial Intelligence in the Search for Worlds Beyond Our Solar System"
Lebanese American University Department of Computer Science and Mathematics
- 2017 "JWST's Capabilities and Limitations for Time Series Observations"
JWST Proposal Planning Workshop
- 2017 "How to propose for and use NIRISS for JWST"
JWST Proposal Planning Workshop
- 2017 "Exoplanets in the Era of James Webb"
Space Telescope Science Institute Community Lectures
- 2016 "Machine Learning Capabilities for Space Based Research: Exoplanet Characterization with Space-borne Observatories."
Lebanese American University Department of Computer Science and Mathematics
- 2016 "Exoplanets in the Era of James Webb"
NASA Earths in Other Solar Systems Institute
- 2016 "Time Series Observations with the James Webb Space Telescope"
Canadian National Research Council
- 2016 "Lessons Learned from HST to Optimize JWST"
Canadian National Research Council
- 2015 "Diagnosing Clouds and Hazes in Exoplanet Atmospheres"
University of Maryland Department of Astronomy
- 2015 "Transmission Spectroscopy for Exoplanet Atmospheres"
American University of Beirut Department of Physics
- 2014 "Exoplanets: Super-Earths, Warm Neptunes, and Hot Jupiters" (Plenary)
MEARIM III: The Third Middle-East and Africa Regional IAU Meeting
<http://www.mearim3.org/>
- 2014 "Transmission Spectroscopy for Comparative Planetology"
NASA Infrared Processing and Analysis Center
IPAC Lunch Talk (Dec. 17th), Fraine J.D., Deming D., Jordán, A., Knutson, H.
- 2014 "Transmission Spectroscopy for Comparative Planetology"
California Institute of Technology Division for Geological and Planetary Sciences
Kliegel Lecture in Planetary Science, Fraine J.D., Deming D., Jordán, A., Knutson, H.
- 2014 "Molecular Absorption from an Exo-Neptune"
California Institute of Technology Division for Geological and Planetary Sciences
Yuk Lunch Talk (Feb. 4th), **Fraine J.D.**, Deming D., Benneke, B., Knutson, H.,
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- Jordán, A., Espinoza, N., Madhusudhan, N., Wilkins, A., Todorov, K.
- 2014 “Molecular Absorption from an Exo-Neptune”
University of California Santa Cruz FLASH Talk (Jan. 31st)
Fraine J.D., Deming D., Benneke, B., Knutson, H., Jordán, A., Espinoza, N., Madhusudhan, N., Wilkins, A., Todorov, K.
- 2014 “Clouds and Haze in the Atmosphere of the Super-Earth GJ1214b Using Spitzer”
Harvard-Smithsonian Center for Astrophysics, Optical and IR Astronomy Lecture (Jan. 29rd), **Fraine J.D.**, Deming D., Benneke, B., Knutson, H., Jordán, A., Espinoza, N., Madhusudhan, N., Wilkins, A., Todorov, K.
- 2014 “Molecular Absorption from an Exo-Neptune”
Massachusetts Institute of Technology, Kavli Institute for Astrophysics Brown Bag Lunch (Jan. 27rd) **Fraine J.D.**, Deming D., Benneke, B., Knutson, H., Jordán, A., Espinoza, N., Madhusudhan, N., Wilkins, A., Todorov, K.
- 2013 “Constraining an Organic Haze on a Super Earth with Spitzer”
Space Telescope Science Institute, Star and Planet Formation Seminar Series (Feb. 15th), **Fraine J.D.** & Deming L.D.

Conference Presentations

- 2018 “The Ultimate Exoplanet Phase Curve Survey: Updated Results from our Seven Planet Spitzer Phase Curve Survey.”
American Astronomical Society Meeting 231
National Harbor, MD, Fraine, J.D., Stevenson, K.B., Bean J., Kataria, T., Rauscher, E.
- 2015 “USING JWST NIRCcam for Exoplanet Observations”
Enabling Transiting Exoplanet Science with JWST
Baltimore, MD, Fraine, J.D., Rieke, M., Greene, T., Line, M., Leisenring, J.
- 2015 “Transmission Spectroscopy for Comparative Planetology”
225th American Astronomical Society Conference
Seattle, WA, Fraine, J.D., Deming, D., Jordán, A., Knutson, H.
- 2014 “Transmission Spectroscopy for Comparative Planetology”
46th American Astronomical Society Division for Planetary Sciences Conference
Tucson, AZ, Fraine J.D., Deming D., Jordán, A., Knutson, H.
- 2014 “Atmosphere of exo-Neptune HAT-P-11b”
Exoclimates III: The Diversity of Planetary Atmospheres
Davos, Switzerland, Fraine J.D., Deming D., Benneke, B., Knutson, H., Espinoza, N., Jordán, A., Madhusudhan, N., Wilkins, A., Todorov, K.
- 2013 “Molecular Absorption from an Exo-Neptune”
45th American Astronomical Society Division for Planetary Sciences Conference

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Denver, CO, Fraine J.D., Deming D., Benneke, B., Knutson, H., Madhusudhan, N., Wilkins, A., Todorov, K.

- 2013 “*Spitzer* Transits of the Super-Earth GJ1214b and Implications for Its Atmosphere”
44th American Astronomical Society Division for Planetary Sciences Conference
Reno, NV, Jonathan D. Fraine, Drake Deming
- 2011 “Twelve Consecutive Transits of GJ1214b in 20 Days of Continuous Observations”
Spitzer”, Extreme Solar Systems II, Jackson Hole, Wy, Jonathan Fraine, D. Deming,
M. Gillon, B. Demory, S. Seager
- 2007 “Magnetic-Force Enhanced Temperature Gradient”
American Physical Society, APS March Meeting, Jonathan Fraine and Weili Luo

Professional Activity

- 2019 Science Organizing Committee Member Space Telescope Science Institute TESS Data Workshop
- 2019 Member of a NASA Telescope Review Panel
- 2018 Member of a NASA Telescope Review Panel
- 2017 Science Organizing Committee Member Space Telescope Science Institute Enabling Transiting Exoplanet Observations for the James Webb Space Telescope
- 2016 Visiting Scientist at American University of Beirut Department of Physics

Awards and Honors

- 2019 United Nations Panel Member for “Prospects & Ethics of Innovation and Technology in Official Statistics” for Economic and Social Commission of Western Asia
- 2014 Plenary Speaker at The Third Middle-East and Africa Regional IAU Meeting
- 2013 NASA Review Panel Executive Secretary
- 2013 California Institute of Technology Pre-doctoral Fellowship Program
- 2013 University of Maryland - Pontificia Universidad de Católica Joint Degree Program
- 2010 UMD Center for Teaching Excellence Distinguished Teaching Assistants Award
- 2009 Pi Mu Epsilon Mathematics Honor Society Univ. Central Florida Chapter Member
- 2008 JHU Applied Physics Laboratory Summer Internship Program
- 2005 Sigma Pi Sigma Physics Honor Society Univ. Central Florida Chapter Member

Outreach

- 2018 Australian National University National Science Week Tour: “What can we learn from Exoplanet Atmospheres?”; 7 presentations; 5 radio/video/newspaper interviews
- 2018 Lebanese American University TEDx Salon Panel Member “The Future of Human Space Flight and Diversity Experience in the Sciences.”
- 2018 Lebanese American University Astronomy Club Lecture “Exoplanet Atmospheric Science in the Decade to Come”

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- 2016 Lebanese American University Joint Astronomy and Robotics: "Future Space Technology: Scientific Frontiers with the Next Generation Telescopes"
- 2016 Lebanese American University Astronomy Club Lecture: "The Search for Life: What Exoplanets Can Tell Us About Life in the Universe."
- 2016 American University of Beirut Astronomy Club Lecture: "The Search for Life: What Exoplanets Can Tell Us About Life in the Universe."
- 2015 American University of Beirut Department of Physics Public Talk: "What Can Exoplanets Teach Us About Where We Came From?"
- 2015 Lebanese American University Astronomy Club Public Talk: "What Can Exoplanets Teach Us About Where We Came From?"
- 2014 Press Coverage: Conducted 20 independent, international interviews related to the publication of my first authored **Nature** paper; a few examples: Washington Post, NASA News, Nature News, National Geographic, NPR Chico Campus, Naples Daily News, Daily Star Lebanon, Folha de S.Paulo Brazil
- 2014 University of Maryland Observatory Public Talk: "Astrobiology"
- 2012 Assisted ~200 members of the public to view the Venus Transit via local telescopes at the Univ. of Maryland and remote viewing from the Keck Observatories
- 2003 - 2009 Conducted biweekly astronomical viewing for the public at the Robinson Observatory at the University of Central Florida