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Research Interests

My research focuses on how planetary aurorae and magnetospheres are driven by different internal factors (e.g., field-aligned currents, plasmadisk densities and velocities, and ionospheric conductance) and external factors (e.g., solar wind density and velocity, interplanetary magnetic field (IMF), interplanetary coronal mass ejections (ICMEs)). I use remote observations (e.g., HST in the ultraviolet, CXO in the X-ray), in-situ spacecraft measurements (including the *Pioneers 10* and *11*, *Voyagers 1* and *2*, *Ulysses*, *Galileo*, *Cassini*, ACE, *Wind*, and *Juno* missions), solar wind propagation models (e.g., WSA-ENLIL, WSA-, MAS-HUXt, MSWIM2D), and novel algorithms and probabilistic, uncertainty-aware techniques (e.g., keograms, edge- and feature-detection, multi-model ensembles, dynamic time warping, data assimilation, Bayesian inferencing, Gaussian processes) to further our understanding of these systems.

Research & Work Experience

Present Feb 2025	**Visiting Scientist** *Universty of Alberta & Alberta Machine Intelligence Institute* Improving solar wind and space weather forecasting at the Moon and Mars using machine learning, Bayesian statistics, multipoint spacecraft measurements, and propagation modeling.
Feb 2026 Dec 2025	**Visiting Scientist** *Harvard & Smithsonian Center for Astrophysics* Devised techniques to process *Chandra* X-ray Observatory (CXO) observations taken with the new, unsupported off-axis HRC-S imaging mode; interpreted novel observations of Jupiter's X-ray aurorae.
Nov 2025 Mar 2023	**Postdoctoral Research Fellow** *Dublin Institute for Advanced Studies (DIAS)* Investigated the effects of the solar wind on outer planet magnetospheres by developing space weather ensemble forecasts and novel Bayesian models of planetary bow shocks and magnetopauses.
Feb 2023 Sep 2017	**Research Fellow** *Boston University* Investigated the motions of Jupiter's ultraviolet aurorae and how these relate to ionospheric conductance, magnetospheric plasma, and magnetosphere-ionosphere coupling with data and models.

Teaching Experience

Oct 2024 Sep 2023	**Guest Lecturer (PHYC40660 "The Space Environment")** *University College Dublin* As a postdoctoral research fellow, created and gave masters-level lectures introducing the solar wind, planetary magnetospheres, space weather, and space plasmas, with a focus on outer planet magnetospheres.
May 2019 Jan 2019	**Teaching Fellow (AS100 "Cosmic Controversies")** *Boston University* As a research fellow, hosted two undergraduate-level discussion and problem-solving sections to review lecture material, including labs and projects.
Dec 2018 Sep 2018	**Teaching Fellow (AS107 "Life Beyond Earth')** *Boston University* As a research fellow, hosted five, undergraduate-level discussion and problem-solving sections to review lecture material, including weekly quizzes, labs, and projects.
Dec 2017 Jan 2017	**Coadjutant (Coursera MOOC "Analyzing the Universe")** *Rutgers University* As an undergraduate student, held regular office hours to help students with technical problems and scientific questions while analyzing astronomical observations.

Education

Feb 2023	**Ph.D. in Astronomy with Prof. John Clarke** *Boston University* Thesis: ***Shedding New Light on the Enigmatic Motions of Jupiter's Auroral Main Emission***
Sep 2019	**M.A. in Astronomy with Prof. John Clarke** *Boston University*
May 2017	**B.Sc. in Astrophysics and Linguistics with Prof. John Hughes** *Rutgers University* *summa cum laude*, with Highest Honors in Astrophysics and Honors in Linguistics

Mentoring

Jan 2025	Trinity College Dublin (TCD) School of Physics Student (*Name withheld for privacy*)
Aug 2024	Undergraduate Senior Thesis: ***Modeling the Solar Wind in Near-Mercury Space***
Jan 2024	Trinity College Dublin (TCD) School of Physics Student (*Name withheld for privacy*)
Aug 2024	Undergraduate Senior Thesis: ***Mapping Jupiter's Auroral Lights***

Additional Skills & Training

Python, IDL, HTML, CSS, LaTeX	Coding Languages
SPICE (ICY, SpiceyPy; incl. training with NAIF/SPICE team), Git, GitHub	Software
STScI MAST, NASA PDS, AMDA, CCMC, CDAWeb, COHOWeb, NASA SPDF	Data Interfaces

Publications

Owens, M. J., Barnard, L. A., Turner, H., Gyeltshen, D., Edward-Inatimi, N., O'Donoghue, J., Lockwood, M., Watson, S., **Rutala, M. J.**, C.M. Jackman, C. M., Riley, P. (2026) *Driving dynamical inner-heliosphere models with in-situ solar-wind observations*

Hollman, D. M., Jackman, C. M., Domijan, K., Bowers, C. F., Walker, S. J., **Rutala, M. J.**, & Fogg, A. R. (2026) *Identifying MESSENGER Magnetospheric Boundary Crossings Using a Random Forest Region Classifier*

Bowers, C. F., Jackman, C. M., Jia, X., Hadid, L., Sun, W., Hayes, L., Dewey, R. M., Burkholder, B. L., Hollman, D. M., Cervantes, S., Huybrighs, H., & **Rutala, M. J.** (2025) *MESSENGER Observations of Mercury's Altered Magnetosphere during a sub-Alfvénic ICME event: Evidence for Asymmetric Alfvén Wings*

Melin, H., Stallard, T. S., O'Donoghue, J., Moore, L., Tiranti, P. I., Knowles, K. L., Greathouse, T. K., Puertas, M. L., **Rutala, M. J.**, Johnson, R. E., & Thomas, E. M. (2025) *Temporal Variability of the Northern Infrared Aurora of Jupiter as Captured by JWST*

Rutala, M. J., Jackman, C. M., Louis, C. K., Azari, A. R., Bagenal, F., Joy, S. P., Kurth, W. S., Keebler, T. B., Giles, R. S., Ebert, R. W., Bowers, C. F. & Vogt, M. F. (2025) *New Models of Jupiter's Magnetopause and Bow Shock through the Juno Prime Mission: Probabilistic Location, Shape, and Internally-Driven Variation.* doi:10.1029/2025JA033842

Fogg, A. R., Healy, D., Jackman, C. M., Parnell, A., **Rutala, M. J.**, McEntee, S. C., Walker, S. J., Gallagher, P. T. & Bowers, C. F. (2025) *Bivariate Extreme Value Analysis for Space Weather Risk Assessment: Solar Wind-Magnetosphere Driving in the Terrestrial System.* doi:10.1029/2024SW004176

Bowers, C. F., Jackman, C. M., Jia, X., Slavin, J. A., Saur, J., Holmberg, M. K. G., Dewey, R. M., Heyner, D., Elekes, F., Hadid, L. Z., Lavraud, B., Wang, Y., Huybrighs, H. L. F., **Rutala, M. J.**, Fogg, A. R., Lee, S. B. & Hollman, D. M. (2025) *MESSENGER Observations of a Possible Alfvén Wing at Mercury Driven by a Low Alfvénic Mach Number Interplanetary Coronal Mass Ejection.* doi:10.1029/2024JA033619

Bowers, C. F., Jackman, C. M., Azari, A. R., Smith, A. W., Wright, P. J., **Rutala, M. J.**, Sun, W. & Healy, A. (2024) *Estimating Interplanetary Magnetic Field Conditions at Mercury's Orbit from MESSENGER Magnetosheath Observations Using a Feedforward Neural Network.* JGR: Machine Learning and Computation, doi:10.1029/2024JH000239

Azari, A. R., Abrahams, E., Sapienza, F., Halekas, J., Biersteker, J., Mitchell, D. L., Pérez, F., Marquette, M., **Rutala, M. J.**, Bowers, C. F., Jackman, C. M. & Curry, S. M. (2024) *A Virtual Solar Wind Monitor at Mars with Uncertainty Quantification Using Gaussian Processes.* JGR: Machine Learning and Computation, doi:10.1029/2024JH000155

Rutala, M. J., Jackman, C. M., Owens, M. J., Tao, C., Fogg, A. R., Murray, S. A. & Barnard, L. (2024) *A Multi-Model Ensemble System for the Outer Heliosphere (MMESH): Solar Wind Conditions near Jupiter.* JGR: Space Physics, doi:10.1029/2024JA032613

Rutala, M. J., Clarke, J. T., Vogt, M. F. & Nichols, J. D. (2024) *Variation in the Pedersen Conductance near Jupiter's Main Emission Aurora: Comparison of Hubble Space Telescope and Galileo Measurements.* JGR: Space Physics, doi:10.1029/2023JA032122

McEntee, S. C., Jackman, C. M., Weigt, D. M., Louis, C. K., Dunn, W. R., Boudouma, A., Connerney, J. E. P., Kurth, W. S., Kraft, R., Branduardi-Raymont, G., Gladstone, G. R. & **Rutala, M. J.** (2023) *Long Exposure Chandra X-Ray Observation of Jupiter's Auroral Emissions during Juno Plasmasheet Encounters in September 2021.* JGR: Space Physics, doi:10.1029/2023JA031901

Rutala, M. J., Clarke, J. T., Mullins, J. D. & Nichols, J. D. (2022) *Illuminating the Motions of Jupiter's Auroral Dawn Storms.* JGR: Space Physics, doi:10.1029/2022JA030448

Vogt, M. F., **Rutala, M. J.**, Bonfond, B., Clarke, J. T., Moore, L. & Nichols, J. D. (2022) *Variability of Jupiter's Main Auroral Emission and Satellite Footprints Observed with HST during the Galileo Era.* JGR: Space Physics, doi:10.1029/2021JA030011

Shinbrot, T., **Rutala, M. J.** & Herrmann, H. (2017) *Surface Contact Charging.* Physical Review E, doi:10.1103/PhysRevE.96.032912

Shinbrot, T., **Rutala, M. J.**, Montessori, A., Prestininzi, P. & Succi, S. (2015) *Paradoxical Ratcheting in Cornstarch.* Physics of Fluids, doi:10.1063/1.4934709

Awards

Oct 2024	**CXO GO 26100029 & HST GO 17872 (Co-I)**, 58ks (CXO) + 4 orbits (HST) imaging of Jupiter's FUV & EUV aurorae *Joining Juno's last Orbits: A Multi-Wavelength Perspective*
July 2024	**HST GO 17812 (PI)**, 8 orbits of long-slit echelle spectroimaging *Unraveling a Decades-long mystery: Identifying the Atmospheric and Magnetospheric Drivers of the Jovian Hydrogen Ly-α Bulge*
June 2021	**MASGC Research Fellowship** *Local Dominance of Jupiter's Corotation-Enforcement Current System in Driving Auroral Emissions Features*
June 2020	**MASGC Research Fellowship** *Towards Deeper Insights into Jupiter's Dawn Storm*
Oct 2014	**NJSGC Research Fellowship** *Size Segregation in the Regolith of Asteroid 25143 Itokawa*

Invited Seminars & Talks

Jan 2026	***Casting New Light on Jupiter's Unexplored XUV Aurorae*** **Invited Seminar**, Harvard & Smithsonian Center for Astrophysics
Dec 2025	***New Models of Jupiter's Magnetopause and Bow Shock: Probabilistic Locations, Shapes, and Internally-Driven Variation*** **Invited Talk**, American Geophysical Union Fall meeting
Oct 2025	***Exploring the Internal and External Drivers of Gas Giant Aurorae and Magnetospheres*** **Invited Seminar**, Queen's University Belfast, Belfast, UK
Sep 2025	***Data-driven, Probabilistic Solar Wind Reconstruction Beyond the Earth*** **Talk**, Machine Learning in Heliophysics Conference
Aug 2025	***Data-assimilative, Probabilistic Reconstruction of the Solar Wind in the Outer Heliosphere*** **Talk**, Solar Wind-Interstellar Medium (SWIM) Workshop
June 2025	***Forecasting the Outer Heliosphere Solar Wind using Gas Giant Radio Aurorae*** **Talk**, Planetary, Solar, and Heliospheric Radio Emissions X
May 2025	***Exploring the External Drivers of Gas Giant Magnetospheres with Solar Wind Models & Meta-Models*** **Invited Seminar**, Northumbria University, Newcastle upon Tyne, UK
Apr 2025	***Solar Wind Models & Meta-Models in the Outer Heliosphere: Exploring the External Drivers of Gas Giant Magnetospheres*** **Invited Seminar**, MIT Haystack Observatory, Westford, MA
July 2024	***Revisiting the Form of the Jovian Bow Shock and Magnetopause*** **Talk**, Magnetospheres of the Outer Planets conference
July 2024	***Background Solar Wind Conditions during the Juno Mission*** **Poster**, Magnetospheres of the Outer Planets conference
June 2024	***Solar Wind Coupling to Jupiter's Magnetosphere: Statistical Views of a Dynamic System***

	Invited Seminar, Lancaster University, Lancaster, UK
Apr 2024	***The Balance of Internal and External Drivers in Gas Giant Magnetospheres*** **Invited Talk**, European Geophysical Union conference
Dec 2023	***An Ensemble Modeling Framework for Propagating Solar Wind Conditions to Jupiter*** **Talk**, American Geophysical Union Fall meeting
July 2022	***Shedding New Light on the Enigmatic Motions of Jupiter's Auroral Main Emission*** **Talk**, Magnetospheres of the Outer Planets conference
Dec 2021	***The role of Corotation Enforcement Currents in driving the Behavior of Jupiter's Ultraviolet Main Emission*** **Talk**, American Geophysical Union Fall meeting
July 2021	***Illuminating the Physics behind the Motions of Jupiter's Auroral Dawn Storms*** **Poster**, Magnetospheres of the Outer Planets conference
Dec 2020	***Illuminating the Physics of Jupiter's Auroral Dawn Storms*** **Poster**, American Geophysical Union Fall meeting
June 2019	***New Insights into Jupiter's Dawn Storms*** **Poster**, Magnetospheres of the Outer Planets conference
July 2018	***Characterizing Local and Interplanetary Control of Jupiter's Auroral Dawn Storms using HST and Juno*** **Poster**, Magnetospheres of the Outer Planets conference
May 2015	***Size Segregation in Asteroid Regolith*** **Poster**, New Jersey Space Grant Consortium conference
Apr 2015	***Size Segregation in Asteroid Regolith*** **Poster**, Aresty Research Symposium
Aug 2014	***Paradoxical Ratcheting in Oobleck*** **Poster**, Aresty Summer Research Symposium

Academic Service

Panelist for NASA ROSES grant proposals
Peer-reviewer for the Astrophysical Journal, Geophysical Research Letters

Memberships & Recognitions

present	**Fellow of the Royal Astronomical Society**
present	**Member of the American Geophysical Union**
May 2019	**Outstanding Teaching Fellow in the Department of Astronomy**, Boston University
May 2017	**Honors Scholar**, Rutgers University
May 2017	**Richard T. Weidner Physics Prize**, Rutgers University
Mar 2016	**Phi Beta Kappa Scholar**, The Phi Beta Kappa Society
Sep 2015	**Herman Y. Carr Scholarship**, Rutgers University

Outreach

Present June 2023	**DIAS Dunsink Observatory Public Visitor Night** Hosted at the DIAS Dunsink Observatory, public visitor nights include tours of the historic observatory buildings, presentation on Ireland's contributions to space sciences, public research lectures, and night sky viewings.
Feb 2023 Sep 2017	**Boston University Public Open Night** An event hosted by the graduate students at Boston University which invites the public to view the night sky and learn more about astronomy.
Apr 2022	**Boston University Academy Open Night** An open-night-like event with physical demonstrations of spectroscopy and plasma dynamics for students of the Boston University Academy interested in studying science and astronomy.
Aug 2019	**GWISE Open Night** An open-night-like event held for the members of the Graduate Women In Science and Engineering group at Boston University.
July 2018	**Precollege Women Open Night** An open-night-like event for held for precollege women interested in studying science in college.
June 2018	**Space Science for Kids** An educational event for elementary- and middle-school children, coinciding with the 30^{th} anniversary of the Center for Space Physics at Boston University.

Leadership

Apr 2022 Aug 2018	**Graduate Student Event Coordinator** Coordinated weekly events for students, postdocs, and faculty.
Sep 2019 Sep 2018	**Graduate Student Representative** Represented the interests of the graduate students to departmental faculty, so that students could anonymously voice questions or complaints; arranged weekly journal clubs and seminars for students to present their own research.