Matthew James Rutala

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Last updated: June 17, 2025

Research Interests

My research to-date 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), and the sizes and shapes of planetary bow shocks and magnetopauses). 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*, *Juno* missions), solar wind propagation models (e.g., WSA-ENLIL, WSA-, MAS-HUXt, MSWIM2D), and novel techniques (e.g., keograms, soft edge detection, multi-model ensembles, dynamic time warping, Bayesian inferencing, data assimilation, uncertainty quantification) to further our understanding of these systems.

Research Experience

Present March 2023	**Dublin Institute for Advanced Studies (DIAS)** *Postdoctoral Research Fellow* Investigated the effects of the solar wind on outer planet magnetospheres by developing space weather ensemble forecasts for and novel Bayesian models of planetary bow shocks and magnetopauses.
February 2023 September 2017	**Boston University** *Research Fellow* 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

October 2024 September 2023	**University College Dublin** *Guest Lecturer (PHYC40660 "The Space Environment")* Created and gave masters-level guest lectures introducing the solar wind, planetary magnetospheres, space weather, and space plasmas, with focus on the magnetospheres of the outer planets.
May 2019 January 2019	**Boston University** *Teaching Fellow (AS100 "Cosmic Controversies")* Hosted two undergraduate-level discussion and problem-solving sections to review lecture material, including labs and projects.
December 2018 September 2018	**Boston University** *Teaching Fellow (AS107 "Life Beyond Earth')* Hosted five, undergraduate-level discussion and problem-solving sections to review lecture material, including weekly quizzes, labs, and projects.
December 2017 January 2017	**Rutgers University** *Coadjutant (Coursera MOOC "Analyzing the Universe")* Held regular office hours to help students with technical problems and scientific questions while analyzing astronomical observations.

Education

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

Mentoring

Fall 2024	Trinity College Dublin (TCD) School of Physics Student (*Name withheld for privacy*) Undergraduate Senior Thesis: ***Modeling the Solar Wind in Near-Mercury Space***
Fall 2023	Trinity College Dublin (TCD) School of Physics Student (*Name withheld for privacy*) Undergraduate Senior Thesis: ***Mapping Jupiter's Auroral Lights***

Additional Skills & Training

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

Publications

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.** (submitted) *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. (submitted) *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

October 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*
October 2014	**NJSGC Research Fellowship** *Size Segregation in the Regolith of Asteroid 25143 Itokawa*

Invited Seminars & Talks

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
April 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
April 2024	*The Balance of Internal and External Drivers in Gas Giant Magnetospheres* **Invited Talk**, European Geophysical Union conference
December 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
December 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
December 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
April 2015	*Size Segregation in Asteroid Regolith* **Poster**, Aresty Research Symposium
August 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
March 2016	**Phi Beta Kappa Scholar**, The Phi Beta Kappa Society
September 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.
February 2023 September 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.
April 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.
August 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

April 2022 August 2018	**Graduate Student Event Coordinator** Coordinated weekly events for students, postdocs, and faculty.
September 2019 September 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.