

Noé LUGAZ

Research Associate Professor

Space Science Center and Department of Physics

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Education

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| University of Michigan, Ann Arbor, MI | 08/2002 – 12/2006 |
| Ph.D. Space Science | 2007 |
| M.Sc. Atmospheric and Space Sciences | 2003 |
| Institute of Aeronautics and Aerospace (Supaéro), Toulouse, France | 09/2000 – 06/2002 |
| M. Eng. Aerospace Engineering (Diplôme d'ingénieur) | 2003 |

Academic Appointments

Space Science Center, University of New Hampshire

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| Research Associate Professor (Dept. of Physics) | 08/2016 – present |
| Research Assistant Professor | 05/2013 – 08/2016 |
| Research Scientist III | 03/2012 – 05/2013 |

Institute for Astronomy, University of Hawaii

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| Assistant Astronomer (research faculty) | 06/2009 – 03/2012 |
| Postdoctoral Researcher (Mentor: I. I. Roussev) | 01/2007 – 05/2009 |

Kyoto University, JSPS Fellow

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| Visiting Researcher (Host: K. Shibata) | 10/2010 – 05/2011 |
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AOSS, University of Michigan

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| Graduate Student Research Assistant (Advisors: T. I. Gombosi & W. B. Manchester) | 08/2003 – 12/2006 |
| Research Assistant (Advisor: J. H. Waite) | 11/2002 – 08/2003 |

Narrative

My research in the past fifteen years has focused on the investigation of coronal mass ejections (CMEs), particularly series of CMEs, and their consequences on Earth's magnetosphere and radiation belts. I received the 2014 Arne Richter award for Outstanding Young Scientists from the European Geosciences Union (awarded to 4 or 5 scientists per year within 7 years of their PhD), for which the citation noted that “[I] made a number breakthrough advances in the subject of coronal mass ejections”. My past work encompasses solar, interplanetary, and magnetospheric/radiation belt physics. I have performed numerical simulations, analyzed remote-sensing observations and in situ measurements, and led a small complete mission proposal. I have received 12 research grants as Principal Investigator in the US for over 5.2 M\$, which has allowed me to develop, since 2008, an independent research program encompassing all these different aspects of space physics. Since 2005, I have published 24 first-authored articles and 50 co-authored articles in peer-reviewed journals (30 ApJ, 13 JGR, 11 Solar Physics, 2 GRL, 3 in Nature Journals), I have a h-index of 30 with 2550 citations (Google Scholar) or h of 28 for 2100 citations (ISI).

From 2013 to 2018, I was a SHINE steering committee member and served as the SHINE workshop coordinator. Under my tenure, SHINE has grown from 160 participants in 2013 to 310 in 2018. I have served as a guest editor for Solar Physics, and I have reviewed over 75 articles. I have been invited to give 21 presentations at the major conferences in my field (COSPAR, AGU, EGU, IAU General Assembly) and I have given an additional 25 first-authored oral presentations. I have conveyed and chaired over 15 sessions at SHINE and AGU since 2009. I am or have been on the PhD thesis committee for three students and I am currently advising a PhD student; since 2009, I also advised 6 undergraduate students. I co-taught a course on space plasma physics at UNH in 2014 and 2017.

Awards

2014 Arne Richter Award for Outstanding Young Scientists of the European Geosciences Union (EGU).

2016 Editors' Citation for Excellence in Refereeing for *JGR-Space Physics*.

2017 Editors' Citation for Excellence in Refereeing for *JGR-Space Physics*.

Grants (> 5.3M\$ as PI since 2008; 3.4M\$ on current awards)

Current or Past PI on NASA Living with a Star ($\times 2$), Heliophysics Supporting Research, Grand Challenge Research (Theory Program), NSF Solar-Terrestrial ($\times 2$), SHINE and National Space Weather Program.

Current as PI

NASA/HGCR, 80NSSC17K0009, **PI** (\$1,587,000) 08/2017 – 07/2020
Physical Origins of Suprathermal Ion Populations Throughout the Heliosphere

Current as Co-I

LWS17/CME, **Co-I** (0.12 FTE) – PI: A. Savcheva (CfA) 2018 – 2022
SHINE, **SP** (0.04 FTE) – PI: R. Winslow (UNH) 2017 – 2019

Current Mission Involvement

STEREO/PLASTIC 1-2 months/year (PI: Galvin) 2015 – present
RBSP/ECT 1-2 months/year (PI: Spence) 2016 – 2018

Past as PI

NASA/LWS NNX15AB87G, **PI** (\$536,000) 12/2014 – 11/2018
NSF/ST AGS1435785, **PI**, (\$335,500) 06/2015 – 05/2018
NSF/ST AGS1433213, **Local PI**, (\$63,500) 06/2015 – 05/2018
NSF/SHINE AGS1460179, **Local PI**, (\$59,000) 07/2015 – 06/2018
NSF/AGS AGS1601877 *SHINE Workshop*, **PI** (\$907,000) 02/2016 – 01/2021
NASA/SHP NNX12AB28G, **PI** (\$366,000) 10/2011 – 05/2016
NSF/SHINE AGS1239699, **PI** (\$252,000) 03/2012 – 02/2015
NSF/ST AGS1239704, **PI** (\$307,000) 12/2011 – 11/2014
NSF/NSWP AGS0819653, **PI** (\$193,000) 08/2008 – 07/2012
NASA/LWS TR&T NNX08AQ16G, **PI** (\$364,000) 05/2008 – 04/2012
NSF/PLR PLR1430750 *SHINE Workshop*, **PI** (\$324,000) 01/2014 – 07/2016
Japanese Society for the **Promotion of Science** Post-doctoral Fellowship (\$37,000) 10/2010 – 05/2011

Advising and Support of Students

PhD advisor Dept of Physics, University of New Hampshire
Tarik Salman (3rd year student) 2017 – present

PhD co-advisor Dept of Physics, University of New Hampshire
Dr. Wenyuan Yu (graduated 11/2016) 2013 – 2016

PhD committee member Dept of Physics, University of New Hampshire
Sam Bingham 2017 – present

PhD committee member Institute for Astronomy, University of Hawaii
Dr. Cooper Downs (graduated 10/2011) 2007 – 2011

Advisor of undergraduate students University of New Hampshire

C. Maillet, *Senior Thesis Advisor*, UNH AY17-18

O. Orellana, UNH Fall 2017

C. Small & T. Manion, UNH Spring 2017

REU Program Institute for Astronomy, University of Hawaii

P. Kintner (U. Rochester, USA) Summer 2011

J. Hernandez-Charpak (U. de los Andes, Colombia) Summer 2009

D. Hoving and J. Harper (with I. Roussev) Summer 2007

Teaching Experience

- Co-lecturer at UNH of senior/graduate 4-credit class PHYS 712/812: *Intro to Space Plasma Physics* in Fall 2014 (20 hours taught, 16 students; 4.05/5 average evaluation) with Dr. Farrugia and in Spring 2017 with Dr. Jichun Zhang (20 hours taught, 10 students, 4.81/5 average evaluation).
- Co-lecturer for graduate seminar: *Solar and Stellar Magnetism* in Fall 2010 at U. Hawaii (4 hours taught).
- Instructor for the *Numerical and Visualization Laboratory* at the SPD/SPS Summer School in Maui, HI in July 2008 (6 hours taught).
- Graduate Student Instructor for AOSS 464: *Introduction to Space Environment* in the Fall Semesters of 2005 and 2006 at Univ. Michigan (grader, office hours, substitute lecturer).
- Participant in the CfAO workshop *Rethinking Science Learning and Thinking* in Maui, HI (2007).

Public Outreach Experience

- Mentor for high school students as part of the UNH/SMART program (1 month/year, 2014–2015, 2017).
- *Ballon Launches Introduce Students to Space Science* by Smith, Bloser, **Lugaz**, Broad, Gloezler, and Levergood, *EOS*, **97 (23)**, 14-19, 2016, http://eos.org/wp-content/uploads/2016/11/01-Dec_magazine.pdf
- Co-Investigator (PI: M. Kadooka) for the NASA-funded Hawaii Center for Advancing Systemic Heliophysics Education (EPO grant: 01/2010 –03/2012).
- Participant in the yearly IfA Manoa open house (2007–2010, speaker in 2010).

Professional Organizations

Service and Memberships

- NSF/SHINE Workshop Coordinator and Steering Committee Member (2013 – 2018).
- NCAR Non-NSF Proposal Review Panelist (2018–2019).
- Member of the Scientific Organizing Committee (SOC) of the International Study of Earth-Effecting Solar Transients (ISEST) program of SCOSTEP (2012 – 2018).
- Member of the SOC of session D2.5 at COSPAR 2014 and D2.1 at COSPAR 2012.
- Convener and Chair of 10 SPA/SH sessions at the Fall AGU meetings (2009–2018).
- Session convener for AGU-AOGS 2012 and AGU-Meeting of the Americas 2013 meetings.
- Working Group Leader for 8 sessions at SHINE workshops (2010–2015, 2017).
- Organizer of CME-CME interaction workshop in Oxford, UK (2014).
- Member of the SOC: 2nd workshop on Remote-Sensing of the Heliosphere, Aberystwyth, Wales, 2011.
- Organizer of New England Space Science Consortium meeting on CMEs in October 2012.
- Chair (2012–2014) and Member (2009 – 2015) of the Popular Writing Award Committee of the Solar Physics Division of the American Astrophysical Society.
- Member of American Geophysical Union (2004 – present) and American Astrophys. Society (2007 – 2011).

Reviewing and Editing Activities

- Panel Chair for NASA ROSES panel (2013).
- Panelist for NASA Heliophysics Theory Program (2010), SR&T/HSR (2012, 2016) and HGI (2016, 2017).
- Panelist for NSF/SHINE 2012 program, NSF/AGS 2014 post doctoral program and NSF/AGS 2017 program.
- Mail-in reviewer since 2009 for NSF/SHINE and NSF/ST, NASA/SHP, NASA/HTP, NASA/HGI, NASA Post-doctoral Program (NPP), as well as Flemish and Georgian programs (~10 proposals/year).
- Guest Editor for Topical Issue of Solar Physics (07/2013).
- Multiple manuscripts refereed for Nature Physics, the Astrophysical Journal, Astronomy & Astrophysics, GRL, Journ. Geophys. Res., Solar Physics, JASTP, Space Weather and Adv. Space Res.
- Additional manuscripts refereed for ApJ Letters, Nature Comm., Space Science Reviews, Annales Geophysicae, among others.
- 75 manuscripts reviewed since 2006 (10/year since 2015).
- Judge for SPA Student Poster Award at the Fall AGU meeting (2009–2013, 2015).

Service at UNH

- Member of the Physics Department Graduate Curriculum Committee (2013 – present).
- Elected Member of the Research Faculty Council (Two terms: 2015 – 2018), Chair of the RFC (2017–2018).
- Member of the Ad-Hoc UNH Senate Committee for Lecturers, Clinical, Extension and Research Faculty Involvement in UNH Senate (2015).

Presentations

Seminars and Colloquia (26)

- 2018:** University of Massachusetts at Lowell (Lowell, MA)
- 2016:** University of Massachusetts at Lowell (Lowell, MA) – University of Delaware (Newmark, DE)
- 2015:** Boston University (Boston, MA)
- 2014:** NRL (Washington, DC) – Harvard/SAO (Cambridge, MA)
- 2013:** NASA/GSFC (Greenbelt, MD) – KU Leuven (Leuven, Belgium) – University of Texas at Dallas (Richardson, TX).
- 2012:** Boston College (Boston, MA) – University of New Hampshire (Durham, NH) – Southwest Research Laboratory (Boulder, CO).
- 2011:** University of Alabama in Huntsville (Huntsville, AL) – UNH (Durham, NH) – University of Nagoya (Nagoya, Japan) – NAOJ (Tokyo, Japan) – Tokyo University (Tokyo, Japan) – NOAC (Beijing, China) – Key Laboratory for Space Weather (Beijing, China) – Kyoto University (Kyoto).
- 2010:** Kyoto University (Kyoto, Japan) – Observatoire de Meudon/LESIA (Paris, France).
- 2009:** NASA/GSFC (Greenbelt, MD) – George Mason University (Fairfax, VA) – JAXA (Tokyo, Japan).
- 2006:** University of Hawaii (Honolulu, HI).

Invited Oral Presentations as First Author (26)

- 2019:** AGU Chapman Conference on Space Weather (Pasadena, CA)
- 2018:** SCOSTEP Quadrennial Symposium (Plenary Talk) (Toronto, ON) – European Geosciences Union meeting (Vienna, Austria) – 17th Annual International Astrophysics Conference (Santa Fe, NM)
- 2017:** Joint JpGU/AGU Meeting (Tokyo, Japan)
- 2016:** AGU Fall Meeting (San Francisco, CA) – First VarSITI General Assembly (Albena, Bulgaria)
- 2015:** IAU General Assembly (Honolulu, HI) – ASTRONUM 2015 (Avignon, France).
- 2014:** LWS Science Meeting (Portland, OR) – SHINE workshop (Telluride, CO) – European Geosciences Union meeting Award Lecture (Vienna, Austria).
- 2013:** IAU 300 (Paris, France) – European Geosciences Union meeting (Vienna, Austria).
- 2012:** In-situ Heliospheric Science Symposium (Laurel, MD) – COSPAR D2.1 (Mysore, India) – COSPAR E2.6 (Mysore, India) – IRAP Heliosphere workshop (Toulouse, France).
- 2011:** ILWS 4 (Beijing, China) – ISROSES-II meeting (Borovets, Bulgaria).
- 2010:** Fall AGU (San Francisco, CA) – COSPAR (Bremen, Germany) – Western Pacific Geophysics Meeting (Taipei, Taiwan) – European Geosciences Union meeting (Vienna, Austria).
- Earlier:** SHINE 2009 (Wolfville, N. S., Canada) – SHINE 2007 (Whistler, B. C., Canada).

Contributed Presentations (120+)

- 35+ contributed oral talks as first or presenting author since 2006 (including at AGU, EGU, COSPAR, TESS, IAU Symposium 257, CAWSES-2 symposium, Solar Wind 12 and STEREO-4 meetings).
- 30+ poster presentations as first author since 2004.
- 75+ conference presentations as co-author, including 10 invited talks.

Published Work

Book Chapters (2)

Lugaz, N., Eruptive Prominences and Their Impact on the Earth and Our Life, in *Solar Prominences*, editors: J.-C. Vial and O. Engvold, *Astrophysics and Space Science Library, Springer*, 2015, **415**, 433-453.

Lugaz, N., Space Weather at Earth and in the Solar System, in *The Sun: A Guide to Stellar Astrophysics*, editors: O. Engvold, J.-C. Vial and A. Skumanich, *Elsevier*, 2019, 335-361, doi:10.1016/C2017-0-01365-4.

Articles in Refereed Journals (74)

24 first authored publications in peer-reviewed journals.

14 second or third-authored and 36 additional co-authored publications in peer-reviewed journals.

Scopus: Citations: 2125 – h-index: 28 – Citations in 2017/2018: 353/309 – 18 articles with more than 50 citations each.

<http://tinyurl.com/NLugazADS>

<http://www.researcherid.com/rid/C-1284-2008>

First-authored Articles (24)

900+ citations, h = 17, 9 articles with more than 50 citations. 145/90 citations in 2017/2018.

2 first-authored articles published per year, on average, since 2008.

[F24] **Lugaz, N.**, Farrugia, C. J., Winslow, R. M., Al-Haddad, N., Galvin, A. B., Nieves-Chinchilla, T., Lee, C. O., Janvier, M., On the Spatial Coherence of Magnetic Ejecta: Measurements of Coronal Mass Ejections by Multiple Spacecraft Longitudinally Separated by 0.01 AU, *Astrophys. J. Lett. (ApJL)*, 2018, **864**, 7.

[F23] **Lugaz, N.**, Farrugia, C. J., Winslow, R. M., Small, C., Manion, T. and Savani, N. P., Importance of CME Radial Expansion on the Ability of Slow CMEs to Drive Shocks, *Astrophys. J. (ApJ)*, 2017, **848**, 75.

[F22] **Lugaz, N.**, Temmer, M., Wang, Y., Farrugia, C. J., The Interaction of Successive Coronal Mass Ejections: A Review, *Solar Physics*, 2017, **292**, 64.

[F21] **Lugaz, N.**, Farrugia, C. J., Winslow, R., Al-Haddad, N., Kilpua, E. K. J., Riley, P., Factors Affecting the Geo-effectiveness of Shocks and Sheaths at 1 AU, *Journ. Geophys. Res. (JGR)*, 2016, **121**, 10,861-10,879.

[F20] **Lugaz, N.**, Farrugia, C. J., Huang, C.-L., Winslow, R. M., Spence, H. E., Schwadron, N. A. Earth's magnetosphere and outer radiation belt under sub-Alfvénic solar wind, *Nature Communications*, 2016, **7**, 13001.

[F19] **Lugaz, N.**, Farrugia, C. J., Huang, C.-L., Spence, H. E., Extreme Geomagnetic Disturbances Due to Shocks Within CMEs, *Geophys. Rev. Lett. (GRL)*, 2015, **42**, 4694-4701.

[F18] **Lugaz, N.**, Farrugia, C. J., Smith, C. W., Paulson, K., Shocks inside CMEs: A Survey of Properties from 1997 to 2006, *JGR*, 2015, **120**, 2409-2427.

[F17] **Lugaz, N.** and Farrugia, C. J., A New Class of Complex Ejecta Resulting From the Interaction of Two CMEs and Its Expected Geo-Effectiveness, *GRL*, 2014, **41**, 769-776.

[F16] **Lugaz, N.**, Farrugia, C. J., Manchester, W. B. and Schwadron, N., The Interaction of Two Coronal Mass Ejections: Influence of Relative Orientation, *ApJ*, 2013, **778**, 20.

[F15] **Lugaz, N.**, Kintner, P., Effect of Solar Wind Drag on the Determination of the Properties of Coronal Mass Ejections from Heliospheric Images, *Solar Physics*, 2013, **285**, 281-294.

[F14] **Lugaz, N.**, Farrugia, C. J., Davies, J. A., *et al.* The Deflection of the Two Interacting CMEs of 2010 May 24 as Revealed by Combined In-situ Measurements and Heliospheric Imaging, *ApJ*, 2012, **759**, 68.

- [F13] **Lugaz, N.**, Kintner, P., Jian, L., *et al.*, Heliospheric Observations of STEREO-Directed CMEs in 2008–2010: Lessons for Future Observations of Earth-Directed CMEs, *Solar Physics*, 2012, **279**, 497-515.
- [F12] **Lugaz, N.**, Downs, C., Shibata, K., *et al.*, Numerical Investigation of a Coronal Mass Ejection from an Anemone Active Region: Reconnection and Deflection of the 2005 August 22 Eruption, *ApJ*, 2011, **738**, 127.
- [F11] **Lugaz, N.**, Roussev, I. I., Gombosi, T. I., Determining CME Parameters by Fitting Heliospheric Observations: Numerical Investigation of the Accuracy of the Methods, *Adv. Space Res.*, 2011, **48**, 292-299.
- [F10] **Lugaz, N.** & Roussev I. I., Numerical Modeling of Interplanetary Coronal Mass Ejections and Comparison with Heliospheric Images, *JASTP*, 2011, **73**, 1187-1200.
- [F9] **Lugaz, N.**, Accuracy and Limitations of Fitting and Stereoscopic Methods to Determine the Direction of Coronal Mass Ejections from Heliospheric Imagers Observations, *Solar Physics*, 2010, **267**, 411-429.
- [F8] **Lugaz, N.**, Hernandez-Charpak, J. N., Roussev, I. I., *et al.*, Determining the Azimuthal Properties of CMEs from Multi-Spacecraft Remote-Sensing Observations with SECCHI, *ApJ*, 2010, **715**, 493-499.
- [F7] **Lugaz, N.**, Vourlidas, A., & Roussev, I. I., Deriving the Radial Distances of Wide CMEs from Elongation Measurements in the Heliosphere – Application to CME-CME Interaction, *Ann. Geophys.*, 2009, **27**, 3479-3488.
- [F6] **Lugaz, N.**, Vourlidas, A., Roussev, I. I., & Morgan, H., Solar-Terrestrial Simulation in the STEREO Era: The January 24-25, 2007 Eruptions, *Solar Physics*, 2009, **256**, 269-284.
- [F5] **Lugaz, N.**, Vourlidas A., Roussev I. I., Jacobs, C., Manchester, IV, W. B., & Cohen, O., The Brightness of Density Structures at Large Solar Elongation Angles: What is Being Observed by STEREO/SECCHI? *ApJL*, 2008, **684**, L111-114.
- [F4] **Lugaz, N.**, Manchester, IV, W. B., Roussev, I. I., & Gombosi, T. I., Observational Evidence of CMEs Interacting in the Inner Heliosphere Based on MHD Simulations, *JASTP*, 2008, **70**, 598-604.
- [F3] **Lugaz, N.**, Manchester, IV, W. B., Roussev, I. I., Tóth, G., & Gombosi, T. I., Numerical Investigation of the Homologous Coronal Mass Ejections from Active Region 9236, *ApJ*, 2007, **659**, 788-800.
- [F2] **Lugaz, N.**, Manchester, IV, W. B., & Gombosi, T. I., Numerical Simulation of the Interaction of Two Coronal Mass Ejections from Sun to Earth, *ApJ*, 2005, **634**, 651-662.
- [F1] **Lugaz, N.**, Manchester, IV, W. B., & Gombosi, T. I., The Evolution of Coronal Mass Ejection Density Structures, *ApJ*, 2005, **627**, 1019-1030.

Second and Third-authored Articles (14)

340+ citations, 5 articles with more than 30 citations.

- [S14] Salman, T. M., **Lugaz, N.**, Farrugia, C. J., Winslow, R. M., Galvin, A. B., Schwadron, N. A., Forecasting Periods of Strong Southward Magnetic Field Following Interplanetary Shocks, *Space Weather*, 2018, doi:10.1029/2018SW002056.
- [S13] Yu, W., Farrugia, C. J., **Lugaz, N.**, Galvin, A. B., Möstl, C., Paulson, K., Vemareddy, P., The Magnetic Field Geometry of Small Solar Wind Flux Ropes Inferred from their Twist Distribution, *Solar Physics*, 2018, **293**, 165.
- [S12] Winslow, R. M., Schwadron, N., **Lugaz, N.**, Guo, J., Joyce, C. J., Jordan, A. P., Wilson, J. K., Spence, H. E., Lawrence, D. J., Wimmer-Schweingruber, R. F., Mays, M. L., Opening a Window on ICME-driven GCR Modulation in the Inner Solar System, *ApJ*, 2018, **856**, 139.

[S11] Farrugia, C. J., **Lugaz, N.**, Alm, L., Vasquez, B., Argall, M., Kucharek, H. *et al.*, MMS Observations of Reconnection at Dayside Magnetopause Crossings During Transitions of the Solar Wind to Sub-Alfvénic Flow, *JGR*, 2017, **122**, 9934.

[S10] Winslow, R., **Lugaz, N.**, Schwadron, N., Farrugia, C. J., Yu, W., Raines, J., Mays, M. L., Galvin, A. B., Zurbuchen, T. Longitudinal conjunction between MESSENGER and STEREO A: development of ICME complexity through stream interactions, *JGR*, 2016, **121**, 6092-6106.

[S9] Winslow, R., **Lugaz, N.**, Philpott, L., Schwadron, N., Farrugia, C. J., Anderson B., Smith, C. W., Interplanetary Coronal Mass Ejections from MESSENGER orbital observations at Mercury, *JGR*, 2015, **120**, 6101-6118.

[S8] Yu, W., Farrugia, C. J., **Lugaz, N.**, Galvin, A., Kilpua, K. *et al.* A Statistical Analysis of Properties of Small Transients in the Solar Wind 2007-2009: STEREO and Wind Observations, *JGR*, 2014, **119**, 689-708.

[S7] Liu, Y. D., Luhmann, J. G., **Lugaz, N.**, Möstl, C., Davies, J. A., Bale, S. D., Lin, R. P., On Sun-Earth Propagation of Coronal Mass Ejections, *ApJ*, 2013, **769**, 45.

[S6] Bisi, M. M., Harrison, R., **Lugaz, N.**, van Driel-Gesztelyi, L. and Mandrini, C. H., Observations and Modelling of the Inner Heliosphere: Preface and Tribute to the Late Dr. Andy Breen, *Solar Physics*, 2013, **285**, 1-7.

[S5] Möstl, C., Rollett, T., **Lugaz, N.**, Farrugia, C. *et al.*, Arrival Time Calculation for ICMEs with Circular Fronts and Application to STEREO Observations of the 2009 February 13 Eruption, *ApJ*, 2011, **741**, 34.

[S4] Jacobs, C., Roussev, I. I., **Lugaz, N.**, & Poedts, S., The Internal Structure of Coronal Mass Ejections: Are all Regular Magnetic Clouds Flux Ropes, *ApJL*, 2009, **695**, L171-174.

[S3] Morgan, H., Habbal, S. R. & **Lugaz N.**, Mapping the Structure of the Corona Using Fourier Backprojection Tomography, *ApJ*, 2009, **690**, 1119-1129.

[S2] Roussev, I. I., **Lugaz, N.**, & Sokolov, I. V., New Physical Insight on the Changes in Magnetic Topology During CMEs: Case Studies for the 2002 April 21 and August 24 Events, *ApJL*, 2007, **668**, L87-90.

[S1] Elsner, R. F., **Lugaz, N.**, Waite, J. H., *et al.* Simultaneous Chandra X ray, Hubble Space Telescope ultraviolet, and Ulysses Radio Observations of Jupiter's Aurora, *JGR*, 2005, **110**, A01207.

Other Articles with Significant Contributions (15)

[C15] Al-Haddad, N., Poedts, S., Farrugia, C. J., **Lugaz, N.**, Yu, W. and Roussev, I. I., The Magnetic Morphology of Magnetic Clouds: Multi-Spacecraft Investigation of Twisted and Writhed CMEs, *Astrophys. J.*, 2019, *accepted*.

[C14] Manchester, W. B., Kilpua, E., Liu, Y. D., **Lugaz, N.**, Riley, P., Török, T. and Vrsnak, B., The Physical Processes of CME/ICME Evolution, *Space Science Reviews*, 2017, **212**, 1159.

[C13] Winslow, R., Philpott, L., Paty, C., **Lugaz, N.**, Schwadron, N., Johnson, C., Korth, H., Statistical study of ICME effects on Mercury's magnetospheric boundaries and northern cusp region from MESSENGER, *JGR*, 2017, **122**, 4960-4975.

[C12] Yu, W. Farrugia, C. J., Galvin, A. B., **Lugaz, N.**, Luhmann, J., Siminac, K., Kilpua, E. Small Solar Wind Transients at 1 AU: STEREO Observations (2007-2014) and Comparison with Near-Earth Wind Results (1995 - 2014), *JGR*, 2016, **121**, 5005-5024.

- [C11] Lee, C. O., Arge, C. N., Odstrcil, D., Millward, G., Pizzo, V., **Lugaz, N.**, Ensemble Modeling of Successive Halo CMEs: A Case Study, *Solar Physics*, 2015, **290**, 1207-1229.
- [C10] Liu, Y. D., Yang, Z., Wang, R., Luhmann, J. G., Richardson, J. D. and **Lugaz, N.** Sun-to-Earth Characteristics of Two Coronal Mass Ejections Interacting Near 1 AU: Formation of a Complex Ejecta and Generation of a Two-step Geomagnetic Storm, *Astrophysical Journal Letters*, 2014, **793**, L41.
- [C9] Davies, J. A., Perry, C. H., Trines, R. M., Harrison, R. A., **Lugaz, N.**, Möstl, C., Steed, K., Establishing a Stereoscopic Technique for Determining the Kinematic Properties of Solar Wind Transients Based on a Generalised Self-Similarly Expanding Circular Geometry, *ApJ*, 2013, **777**, 167.
- [C8] Rollett, T., Temmer, M., Möstl, C., **Lugaz, N.**, Veronig, A. M. and Möstl, U. V., Assessing a New Method for Deriving the Kinematics of ICMEs with a Numerical Simulation, *Solar Physics*, 2013, **283**, 541-556.
- [C7] Rousev, I., Galsgaard, K., Downs, C., **Lugaz, N.**, Sokolov, I., Moise, E. & Lin, J., Explaining Fast Ejections of Plasma and Exotic X-Ray Emission from the Solar Corona, *Nat. Phys.*, 2012, **8**, 845-849.
- [C6] Downs, C., Rousev, I. I., van der Holst, B., **Lugaz, N.**, and Sokolov I. V., On the Thermodynamic Nature of EUV Waves: Understanding SDO/AIA Observations via Global MHD Simulations, *ApJ*, 2012, **750**, 134.
- [C5] Davies, J. A., Harrison, R. A., Perry, C. H., Möstl, C., **Lugaz, N.** *et al.*, A Self-Similar Expansion Model for Use in Solar Transient Propagation Studies, *ApJ*, 2012, **750**, 23.
- [C4] Al-Haddad, N., Rousev, I. I., Möstl, C., Jacobs, C., **Lugaz, N.**, *et al.*, On the Internal Structure of the Magnetic Field in Magnetic Clouds and ICMEs: Writhe Vs. Twist, *ApJL*, 2011, **738**, L18.
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Narrative

Below, I highlight eleven of my first-authored works as example of the breadth of my research.

A. Numerical Simulations of CME-CME Interaction in the Heliosphere

I pioneered the study of CME-CME interaction via Sun-to-Earth 3-D magneto-hydrodynamical (MHD) simulations during my PhD and have continued to perform the most advanced such studies of multiple CMEs, most recently in 2013.

1. Lugaz, N., Manchester, IV, W. B., & Gombosi, T. I., Numerical Simulation of the Interaction of Two Coronal Mass Ejections from Sun to Earth, *Astrophys. Journ.*, 2005, **634**, 651-662. [97 citations]. *This work represents one example of such advanced simulations. In the past two years, 12 years after its publication, it was cited 20 times, highlighting the impact this study has had on the field.*

2. Lugaz, N., Vourlidas, A., Roussev, I. I., & Morgan, H., Solar-Terrestrial Simulation in the STEREO Era: The January 24-25, 2007 Eruptions, *Solar Physics*, 2009, **256**, 269-284. [50 citations]. *The twin STEREO spacecraft were launched in 2006, with, onboard, a new generation of instrument: white-light heliospheric imagers (HIs). This is the second of a series of two papers in 2008-2009 that looked at the first CME remotely observed by STEREO, what was in fact a series of two interacting CMEs.*

B. Methods to Determine CME Properties from Heliospheric Remote Observations

The first few years of HI observations of CMEs revealed the necessity to develop new methods to derive CME position and kinematics from wide-angle white-light observations. Some of my most seminal papers are the derivation and validation of such new techniques, published between 2009 and 2013. These techniques are routinely used in US, Europe and Asia, for scientific studies but also for space weather forecasting.

3. Lugaz, N., Accuracy and Limitations of Fitting and Stereoscopic Methods to Determine the Direction of Coronal Mass Ejections from Heliospheric Imagers Observations, *Solar Physics*, 2010, **267**, 411-429. [single authored article - 61 citations].

4. Lugaz, N., Hernandez-Charpak, J. N., Roussev, I. I., et al., Determining the Azimuthal Properties of CMEs from Multi-Spacecraft Remote-Sensing Observations with SECCHI, *Astrophys. Journ.*, 2010, **715**, 493-499. [93 citations].

5. Lugaz, N., Vourlidis, A. & Roussev, I. I., Deriving the Radial Distances of Wide CMEs from Elongation Measurements in the Heliosphere – Application to CME-CME Interaction, *Ann. Geophys.*, 2009, **27**, 3479-3488. [100 citations].

In this series of papers, I derive and test what is referred to as the “harmonic mean” (HM) method, for single and stereoscopic observations. Some of these works were done in association with undergraduate summer students that I supervised, Paul Kintner (now a PhD student at Univ. of Washington) and Jorge Hernandez-Charpak (now a PhD student at CU-Boulder).

C. Study of CME-CME Interaction with Combined In situ and Remote Observations

Following the derivation of these new techniques, I focused on improving our physical understanding of CME-CME interaction and CME propagation. I contributed as co-author to many such works from 2012 to 2015.

6. Lugaz, N., Farrugia, C. J., Davies, J. A., et al. The Deflection of the Two Interacting CMEs of 2010 May 24 as Revealed by Combined In-situ Measurements and Heliospheric Imaging, *Astrophys. Journ.*, 2012, **759**, 68. [69 citations – 13 citations in 2018].

Combining remote observations and in-situ measurements, I was able to reveal, for the first time with actual observations, that the interaction of CMEs may result in the deflection of one CME by another.

D. Numerical Simulations of CME Eruption and Coronal Evolution

Starting in 2007, I have studied, via numerical simulations, the eruption and coronal evolution of CMEs. I contributed as second and third authors to a number of studies performed at the University of Hawaii in 2007-2009. During a 7-month stay at Kyoto University, funded by a JSPS fellowship, I performed one of the most advanced numerical studies to date of the topological changes occurring during a CME.

7. Lugaz, N., Downs, C., Shibata, K., et al., Numerical Investigation of a Coronal Mass Ejection from an Anemone Active Region: Reconnection and Deflection of the 2005 August 22 Eruption, *Astrophys. Journ.*, 2011, **738**, 127 [53 citations].

This study revealed how CMEs may deflect and their magnetic field may be composed of a mixture of open and closed field lines due to the magnetic characteristics of their source region.

E. Studies of CMEs, Shocks and their Geo-Effectiveness Using In Situ Measurements

Since 2015, I have performed a number of investigations of shocks driven by CMEs, focusing on the occurrence of shocks inside magnetic ejecta and their geo-effects. This has taken my research to a new direction, focusing primarily on in situ measurements. Assessing the impact of such recent work is not straight-forward but recent citations have convinced me that this work will prove as impactful as my previous works using remote observations and numerical simulations. An example of such a study, published in November 2016 and which has already been cited 18 times in two years is given below, followed by my latest work on multi-spacecraft measurements of CMEs.

8. Lugaz, N., Farrugia, C. J., Winslow, R., Al-Haddad, N., Kilpua, E. K. J., Riley, P., Factors Affecting the Geoeffectiveness of Shocks and Sheaths at 1 AU, *Journ. Geophys. Res.*, 2016, **121**, 10861-10879. [18 citations].

9. Lugaz, N., Farrugia, C. J., Winslow, R., Al-Haddad, N., Galvin, A. B., Nieves-Chinchilla, T., Lee, C.

O., Janvier, M., On the Spatial Coherence of Magnetic Ejecta: Measurements of Coronal Mass Ejections by Multiple Spacecraft Longitudinally Separated by 0.01 AU, *Astrophys. J. Lett.*, 2018, **864**, 7.

F. Studies of CME Effects on Earth's Radiation Belts

Starting in 2015, I have combined dayside magnetospheric measurements with Geotail, THEMIS and radiation belt measurements with RBSP and the GOES spacecraft to investigate how CMEs, shocks and series of CMEs affect Earth's radiation belt.

10. Lugaz, N., Farrugia, C., Huang, C., Winslow, R., Spence, H., Schwadron, N. Earth's magnetosphere and outer radiation belt under sub-Alfvénic solar wind, *Nature Communications*, 2016, **7**, 13001.

In this work, published in Nature Communications, I studied a very rare occurrence of a sub-Alfvénic solar wind during the passage over Earth of a CME, and the consequences it had on Earth's radiation belts.

G. Review Papers

I have published two first-authored reviews, one book chapter with one currently in revision, and I am a co-author of a recent review of CME propagation. My most recent review paper is a comprehensive look at the past ten years of observations, measurements and simulations of CME-CME interaction. It covers CME initiation, propagation, the acceleration of particles and the resulting geo-effects associated with successive and interacting CMEs. I expect that this will become the seminal reference to CME-CME interaction.

11. Lugaz, N., Temmer, M., Wang, Y., Farrugia, C. J., The Interaction of Successive Coronal Mass Ejections: A Review, *Solar Physics*, 2017, **292**, 64 [recent review article, 18 citations].