

**Richard A. Frazin**

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EDUCATION:

Ph. D., 2002, Astronomy, University of Illinois at Urbana-Champaign

M.S., 1994, Physics, Georgia State University (Atlanta, GA)

B.S., 1992, Physics, Mathematics, & Astronomy, University of Wisconsin-Madison

WORK HISTORY:

2011 - present, Associate Research Scientist, Dept. of Ocean, Atmospheric and Space Science,  
Univ. of Michigan, Ann Arbor, MI

2007 - 2011, Assistant Research Scientist, Dept. of Ocean, Atmospheric and Space Science,  
Univ. of Michigan, Ann Arbor, MI

2002 - 2007, Postdoctoral Researcher, Dept. of Electrical and Computer Engineering, Univ. of Illinois,  
Urbana, IL

2001 - 2002, Astrophysicist, Smithsonian Astrophysical Observatory,  
Cambridge, MA

1997 - 2001, Pre-doctoral Fellow, Smithsonian Astrophysical Observatory,  
Cambridge, MA

1994-1997 Graduate Teaching Assistant, Astronomy Dept., Univ. of Illinois  
Urbana, IL

1992-1994 Graduate Teaching Assistant, Physics and Astronomy Dept. Georgia State Univ.  
Atlanta, GA

GRANTS AWARDED:

Grants #1-3, listed below, were awarded to the University of Illinois while I was a postdoctoral researcher. While I wrote these proposals and led the research while I was there, I was not eligible to be PI due to my postdoctoral status. It is for this reason that NASA has designation called, "Science-PI," which was my status on Grant #1. I have also been Co-I on numerous other grants.

1. "Determination of the Three-Dimensional Electron Density Distribution in the Extended Solar Corona from SOHO-LASCO," 2004 - 2006, SECGIP03-0000-0088 (NASA: Sun-Earth Connection Guest Investigator Program). PI: Farzad Kamaladadi, Science-PI: **Richard Frazin**.

2. “Driving Global Heliospheric Magnetohydrodynamics (MHD) Models with Tomographically-Determined Lower Boundary Conditions,” 2006 - 2009, Abstract #0555561 (NSF: SHINE program). PI: Farzad Kamalabadi, Co-I’s: **Richard Frazin**, Ward Manchester, Ilia Roussev.
3. “Particle Filtering for Time-Dependent Tomographic Analysis of the Solar Atmosphere,” 2006-2010, Abstract #0620550 (NSF Programs: Mathematical Geosciences, Opportunities for Research CMG). PI: Farzad Kamalabadi, Co-I’s: **Richard Frazin**, Yuguo Chen.
4. “Adding Density to the Wang-Sheeley-Arge Model,” 2008-2011, NNX08AJ09G, (NASA: Heliophysics Guest Investigator Program), **PI: Richard Frazin**, Co-PI’s: W.B. Manchester IV, Nick Arge
5. “Advanced statistical methods for exoplanet detection,” 2011, Keck Futures Initiative Imaging Science Grant, **PI: Richard Frazin**
6. “Stray Light Correction for NASA’s EUV Imaging Instruments,” 2013-2016, NNX13AE22G (NASA: Heliophysics Guest Investigator Programs) **PI: Richard Frazin**

REFEREED JOURNAL PUBLICATIONS:

1. Nuevo, F.A., Huang, Z., Frazin, R., Manchester, W.B. IV, Jin, M., Vsquez, A.M., “Evolution of the Global Temperature Structure of the Solar Corona during the Minimum between Solar Cycles 23 and 24,” *The Astrophysical Journal*, vol. 773, article id. 9 (2013)
2. Frazin, R.A., “Utilization of the Wavefront Sensor and Short-exposure Images for Simultaneous Estimation of Quasi-static Aberration and Exoplanet Intensity,” *The Astrophysical Journal*, vol. 767, article id. 21 (2013).
3. Frazin, R.A., “Coronal Mass Ejection Reconstruction from Three Viewpoints via Simulation Morphing. I. Theory and Examples,” *The Astrophysical Journal*, vol. 761, article id. 24 (2012)
4. Frazin, R.A., Vásquez, A.M., Thompson, W.T., Hewett, R.J., Lamy, P., Llebaria, A., Vourlidis, A., Burkepile, J., “Intercomparison of the LASCO-C2, SECCHI-COR1, SECCHI-COR2, and Mk4 Coronagraphs,” *Solar Physics*, vol. 280, pp. 273-293 (2012).
5. Evans, R.M., Opher, M., Oran, R., van der Holst, B., Sokolov, I.V., Frazin, R., Gombosi, T.I., Vásquez, A.. “Coronal Heating by Surface Alfvén Wave Damping: Implementation in a Global Magnetohydrodynamics Model of the Solar Wind,” *The Astrophysical Journal*, vol. 756, article id. 155, (2012).
6. Huang, Z., Frazin, R.A., Landi, E., Manchester, W.B., Vásquez, A.M., Gombosi, T.I., “Newly Discovered Global Temperature Structures in the Quiet Sun at Solar Minimum,” *The Astrophysical Journal*, vol. 755, article id. 86 (2012).

7. Shearer, P., Frazin, R.A., Hero, A.O. III, Gilbert, A.C., "The First Stray Light Corrected EUV Images of Solar Coronal Holes," *The Astrophysical Journal Letters*, vol. 749, article id. L8, (2012)
8. Jin, M., Manchester, W.B., van der Holst, B., Gruesbeck, J.R., Frazin, R.A., Landi, E., Vásquez, A.M., Lamy, P.L., Llebaria, A., Fedorov, A., "A Global Two-temperature Corona and Inner Heliosphere Model: A Comprehensive Validation Study," *The Astrophysical Journal*, vol. 745, article id. 6, (2012)
9. Vásquez, A.M., Huang, Z., Manchester, W.B. IV, Frazin, R.A., "The WHI Corona from Differential Emission Measure Tomography," *Solar Physics*, vol. 274, pp. 274-259 (2011).
10. Fischer, D.G., Frazin, R.A., Asipauskas, M., Carney, P.S., "Information content of the near field: three-dimensional samples," *Journal of the Optical Society of America A*, vol. 28, pp. 296-306 (2011).
11. van der Holst, B., Manchester, W.B. IV, Frazin, R.A., Vásquez, A.M., Tóth, G., Gombosi, T.I., "A Data-Driven, Two-Temperature Solar Wind Model with Alfvén Waves," *The Astrophysical Journal*, vol. 725, pp. 1373-1383 (2010)
12. Frazin, R.A., Lamy, P., Llebaria, A., Vásquez, A.M., "Three-Dimensional Electron Density from Tomographic Analysis of LASCO-C2 Images of the K-Corona Total Brightness," *Solar Physics*, vol. 265, pp. 19-30 (2010)
13. Vásquez, A.M., Frazin, R.A., Manchester, W.B. IV, "The Solar Minimum Corona from Differential Emission Measure Tomography," *The Astrophysical Journal*, vol. 715, 1352-1365 (2010)
14. Butala, M.D., Hewett, R.J., Frazin, R.A., Kamalabadi, F., "Dynamic Three Dimensional Tomography of the Solar Corona," *Solar Physics*, vol. 262, pp. 495-509 (2010)
15. Vásquez, A.M. & Frazin, R.A., "Multi-Spacecraft 3D Differential Emission Measure Tomography of the Solar Corona: STEREO Results," *Boletín de la Asociación Argentina de Astronomía*, vol. 52, pp. 23-26 (2009)
16. Frazin, R.A., Vásquez, A.M. & Kamalabadi, F., "Quantitative, 3D Analysis of the Global Coronal with Multi-Spacecraft Differential Emission Measure Tomography," *The Astrophysical Journal*, vol. 701, pp. 547-560 (2009)
17. Vásquez, A.M., Frazin, R.A. & Kamalabadi F., "3D Temperatures and Densities of the Solar Corona Via Multi-Spacecraft EUV Tomography: Analysis of Prominence Cavities," *Solar Physics*, vol. 256, pp. 73-85 (2009)
18. Frazin, R.A., Jacob, M., Manchester IV, W.B., Morgan, H., Wakin, M.B., "Towards Reconstruction of CME Density from Only Three Points of View," *The Astrophysical Journal*, vol. 695, pp. 636-641 (2009)

19. Butala, M.D., Frazin, R.A., Chen, Y., Kamalabadi, F., "Tomographic Imaging of Dynamic Objects with the Ensemble Kalman Filter," *IEEE Transactions on Image Processing*, vol. 18, pp. 1573-1587 (2009)
20. Butala, M.D., Kamalabadi, F., Frazin, R.A., Chen, Y., "Dynamic Tomographic Imaging of the Solar Corona," *IEEE Journal of Selected Topics in Signal Processing*, vol. 2, pp. 755-766 (2008)
21. Vásquez, A.M., Frazin, R.A., Hayashi, K., Sokolov, I.V., Cohen, O., Manchester, W.B. IV, Kamalabadi, F., "Validation of Two MHD Models of the Solar Corona with Rotational Tomography," *The Astrophysical Journal*, vol. 682, pp. 1328-1337 (2008)
22. Frazin, R.A., Vásquez, A.M., Kamalabadi, F., Park, H., "Three-Dimensional Tomographic Analysis of a High Cadence LASCO-C2 Polarized Brightness Sequence," *The Astrophysical Journal Letters*, vol. 671, pp. 201-204 (2007)
23. Cohen, O., Sokolov, I.V., Roussev, I.I., Arge, C.N., Manchester, W.B., Gombosi, T.I., Frazin, R.A., Park, H., Butala, M.D., Kamalabadi, F., Velli, M., "A Semi-Empirical Magnetohydrodynamical Model of the Solar Wind," *The Astrophysical Journal Letters*, vol. 654, pp. 163-166 (2007)
24. Frazin, R.A., Butala, M.D., Kemball, A., Kamalabadi, F., "Time-Dependent Reconstruction of Non-Stationary Objects with Tomographic or Interferometric Measurements," *The Astrophysical Journal Letters*, vol. 635, pp. 197-200 (2005)
25. Frazin, R.A. & Kamalabadi, F. "Rotational Tomography for 3D Reconstruction of the White-Light and EUV Corona in the post-SOHO Era," *Solar Physics*, vol. 228, pp. 221-239 (2005)
26. Frazin, R.A., Kamalabadi, F. & Weber, M.A., "On the Combination of Differential Emission Measure Analysis and Rotational Tomography for 3D Solar EUV Imaging," *The Astrophysical Journal*, vol. 628, pp. 1070-1080 (2005).
27. Butala, M.D., Frazin, R.A. & Kamalabadi, F. "Three-Dimensional Estimates of the Coronal Electron Density at Times of Extreme Solar Activity," *Journal of Geophysical Research*, 110, DOI: 10.1029/2004JA010938 (2005)
28. Frazin, R.A. & Kamalabadi, F. "On the Use of Total Brightness Measurements for Tomography of the Solar Corona," *The Astrophysical Journal*, vol. 628, pp. 1061-1069 (2005)
29. Frazin, R.A., Fischer, D.G. & Carney, P.S., "Information Content of the Near-Field: Two-Dimensional Samples," *The Journal of the Optical Society of America A*, vol. 21, pp. 1050-1057 (2004)
30. Carney, P.S., Frazin, R.A., Bozhevolnyi, S., Volkov, V.S., Boltasseva, A., Schotland, J.C., "A Computational Lens for the Near Field," *Physical Review Letters*, vol. 92, n. 16, #163903 (2004)

31. Frazin, R.A., Cranmer, S.R. & Kohl, J.L., “Empirically Determined Anisotropic Velocity Distributions and Outflows of O5+ Ions in a Coronal Streamer at Solar Minimum,” *The Astrophysical Journal*, vol. 597, pp. 1145-1157 (2003)
32. Frazin, R.A. & Janzen, P., “Tomography of the Solar Corona: II. Robust, Regularized, Positive Estimation of the Three-Dimensional Electron Density from LASCO-C2 Polarized White-Light Images,” *The Astrophysical Journal*, vol. 570, pp. 408-422 (2002)
33. Frazin, R.A., “Tomography of the Solar Corona: I. A Robust, Regularized, Positive Estimation Method,” *The Astrophysical Journal*, vol. 530, pp. 1026-1035 (2000)
34. Frazin, R.A., “Optical Path Stability and Fringe Tracking in Optical Stellar Interferometry,” *Optics Communications*, vol. 153, pp. 323-330 (1998)

#### CONFERENCE PUBLICATIONS/PRESENTATIONS:

1. Frazin, R.A., van der Holst B., Manchester, W.B. IV, Landi, E., Lepri, S., Gruesbeck, J., Jin, M. & Oran, R., “Space Weather Modeling Framework Simulation for Solar Orbiter Science,” **invited talk**, Fourth Solar Orbiter Workshop, 2011 (oral).
2. Frazin, R.A., Vásquez, A.M. & Landi, E., “Differential Emission Tomography of AIA Images,” 2010 Fall AGU Meeting.
3. Frazin, R.A., Huang, Z., Lamy, P., Vásquez, A.M. & Manchester, W.B. IV, “Combining Magnetic Field Models with Differential Emission Measure and White-Light Tomography,” Solar Image Processing Workshop V, 2010 (oral).
4. Frazin, R.A., Shearer, P., “Removing the Point-Spread-Function from EUVI Images and the Feb. 25, 2007 Lunar Transit,” Solar Image Processing Workshop V, 2010 (oral).
5. chaired session entitled: “Differential Emission Measure: Techniques and Implications,” 2010 SHINE meeting.
6. Frazin, R.A., Manchester, W.B. IV & Van der Holst, B., “Predicting the Solar Wind Mass Flux at 1 A.U.,” STEREO-SOHO-22 Workshop, 2009 (oral).
7. Frazin, R.A., Vásquez, A.M., Manchester, W.B. & Kamalabadi, F., “Coronal Tomography and Solar Simulations,” **invited talk**, CCHM/CWMM Pre-Review Project Meeting, 2009.
8. Frazin, R.A., Vásquez, A.M. & Kamalabadi, F., “First Results of 3D, Global EUV Tomography from the STEREO Mission: Solar Minimum Results,” Fall 2008 AGU meeting (oral).

9. M. D. Butala, J. Yun, Y. Chen, R. A. Frazin, & F. Kamalabadi, Asymptotic convergence of the ensemble Kalman filter, in Proceedings of the IEEE International Conference on Imaging Processing, San Diego, California, 2008, pp. 825828.
10. Frazin, R.A., Vásquez, A.M., Kamalabadi, F., Jacob, M. & Manchester, W.B., “Tomography with STEREO EUVI and CME Reconstruction from 3 Points of View,” 4th Solar Image Processing Workshop (SIPWork IV), 2008 (oral).
11. Frazin, R.A., Vásquez, A.M. & Kamalabadi, F., “Multi-Spacecraft EUV Tomography and 3D DEM,” 2008 SHINE meeting (oral).
12. Frazin, R.A., Chen, Y., Butala, M.D. & Kamalabadi, F., “Dynamic Tomography of the Solar Corona with the Localized Ensemble Kalman Filter,” **invited talk**, 2008 Joint Statistical Meetings, August 3-7 2008.
13. Frazin, R.A., Jacob, M. & Manchester, W.B. IV, “Reconstruction of CME Electron Density from Only 3 Points of View,” COSPAR 2008
14. Frazin, R.A., Vásquez, A.M. & Kamalabadi, F., “Multi-Spacecraft EUV Tomography and 3D DEM,” oral presentation given at the NSF SHINE workshop, June 2007
15. M. D. Butala, R. A. Frazin, Y. Chen & F. Kamalabadi, “A Monte Carlo Technique for Large-Scale Dynamic Tomography,” in Proceedings of the IEEE International Conference on Acoustic, Speech, and Signal Processing, Honolulu, HI, May 2007, vol 3., pp. 1217-1220.
16. George, A.K., Butala, M.D., Frazin, R.A., Kamalabadi, F. & Bresler, Y., “Time-resolved cardiac CT reconstruction using the ensemble Kalman Filter,” 5th IEEE Int. Symp. on Biomed. Imag. (ISBI 2008), doi: 10.1109/ISBI.2008.4541290
17. Frazin, R. A., Vásquez, A. M. & Kamalabadi, F., “Global, 4D Differential Emission Measure Analysis of EIT 17.1, 19.5 and 28.4 nm Images”, Fall 2007 AGU Meeting
18. Butala, M. D., Frazin, R. A. & Kamalabadi, F., “Time Dependent Tomography of the Solar Corona in Three Spatial Dimensions,” Fall 2007 AGU Meeting
19. Frazin, R.A., Vásquez, A.M., Hayashi, K., Butala, M.D. & Kamalabadi, K., “Combined Magnetic and Tomographic Analysis of the 5/13/05 Event Period,” **invited oral presentation** at the NSF SHINE workshop, August 2007
20. Frazin, R. A., Vásquez, A. & Kamalabadi, F., “3D Coronal Temperatures from Tomographic Analysis of EIT 17.1, 19.5 and 28.4 nm Images,” Fall 2006 AGU meeting
21. Butala, M.D., Frazin, R.A., Chen, Y. & Kamalabadi, F., “A Monte Carlo Technique for Large-Scale Dynamic Tomography,” IEEE ICASSP 2007, doi: 10.1109/ICASSP.2007.367062
22. Frazin, R.A., “Plasma Diagnostics of the Solar Corona with Tomography,” **invited oral presentation** given at on 10/2/06 at the RIARCHE meeting, University of Buenos Aires, Argentina

23. Frazin, R.A., Butala, M., Park, H. & Kamalabadi, F., “Driving Heliospheric MHD Models With Tomographically Determined Lower Boundary Conditions,” **invited oral presentation** given at the NSF SHINE Workshop, July 2006
24. Frazin, R.A., “3D Tomographic Plasma Diagnostics for the Solar Corona,” **invited oral presentation** given at the Princeton Plasma Physics Laboratory on 6/12/06
25. Frazin, R.A., Kamalabadi, F., Machester, W.B. & Roussev, I.I., “Driving models with 3D tomographic reconstructions from white-light, EUV and magnetogram data,” **invited oral presentation** given at the SHINE Workshop, July 2005
26. Frazin, R. A. & Kamalabadi, F., “3D Mapping of Temperatures, Densities and Filling Factors in the Corona With STEREO,” oral presentation given at the AGU-SPD/AAS Joint Assembly Spring 2005
27. Frazin, R. A., Kamalabadi, F. & Butala, M., “On the use of STEREO Measurements for Solar Rotational Tomography,” oral presentation given at the American Geophysical Union, Fall Meeting 2004
28. Butala, M. D., Frazin, R. A. & Kamalabadi, F., “Response of the Electron Density in the Solar Corona to Extreme Solar Events,” oral presentation at the American Geophysical Union, Fall Meeting 2004
29. Frazin, R.A., Cranmer, S.R. & Kohl, J.L., “Empirically Determined Anisotropic Velocity Distributions and Outflows of  $O^{5+}$  ions in a Coronal Streamer at Solar Minimum,” oral presentation given at the 200<sup>th</sup> meeting of the American Astronomical Society 2002
30. Frazin, R.A., Cranmer, S.R. & Kohl, J.L., “Empirically Determined Anisotropic Velocity Distributions and Outflows of  $O^{5+}$  ions in a Coronal Streamer at Solar Minimum,” poster presentation given at the American Geophysical Union, Spring Meeting 2002
31. Frazin, R.A., et al., “UVCS/SOHO Observations of Coronal Streamers,” in *Solar Wind IX*, eds. S.R. Habbal, R. Esser, J.V. Hollweg, & P.A. Isenberg. (Woodbury: American Institute of Physics), pp. 235-238 (1999)
32. Frazin, R.A., et al., “UVCS/SOHO Ion Kinetics in Coronal Streamers,” *Space Science Reviews*, vol. 87, pp. 189-192 (1999)

#### BOOK CHAPTERS:

1. Frazin, R.A., et al., “White Light Inter-calibrations of UVCS, LASCO-C2, and Spartan 201/WLC”, in *The Radiometric Calibration of SOHO*, ISSI Scientific Report SR-002, eds. A Pauluhn, M.C.E. Huber, & R. von Steiger (Noordwijk: ESA Publications) (2002)

2. Romoli, M., Frazin, R.A., Kohl, J.L., Gardner, L.D., Cranmer, S.R., Reardon, K., & Fineschi, S. , “In-flight Calibration of the UVCS White Light Channel,” in *The Radiometric Calibration of SOHO*, ISSI Scientific Report SR-002, eds. A Pauluhn, M.C.E. Huber, & R. von Steiger (Noordwijk: ESA Publications) (2002)

#### Ph.D. THESIS:

Frazin, R.A., “Empirical Constraints on O5+ Outflows and Velocity Distributions in a Solar-Minimum Coronal Streamer,” University of Illinois at Urbana-Champaign (2002)

#### PEER REVIEW SERVICES:

1. Astrophysical Journal/Astrophysical Journal Letters: 6 articles
2. Solar Physics: 4 articles
3. IEEE Signal Processing Magazine: 1 article
4. Journal of Atmospheric and Solar-Terrestrial Physics: 1 article
5. Reviews of Geophysics: 1 article
6. SIAM Journal on Imaging Sciences: 1 article
7. Journal of the Optical Society of America, series A: 1 article
8. NSF: 8 electronic proposal reviews
9. NASA: 14 electronic proposal reviews, 1 review panel
10. Air Force Office of Scientific Research: 2 electronic proposal reviews
11. South Carolinas Institutions of Higher Education: 1 electronic proposal review

#### PUBLIC OUTREACH

1. Invited Lecture: Univ. of Michigan Undergraduate Research Opportunities Program (UROP): *The Sun, It's Corona and 3D Imaging*, November 4, 2009.
2. Invited Lecture: Albion College Department of Physics (Albion, MI), *3D Imaging of the Sun's Corona with Satellite Images*, March 26, 2010.
3. Invited Lecture: Kalamazoo Astronomical Society (Kalamazoo, MI), *3D Imaging of the Sun's Corona with Satellite Images*, June 4, 2010.