

Matthew McKay Hedman

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Education

2002 Ph.D. (Physics), Princeton University
1996 B.A. (Physics and Anthropology), Grinnell College

Research Experience

2013-Present Assistant Professor at University of Idaho

2011-Present Participating Scientist on the Cassini Mission to Saturn

2011-2013 Senior Research Associate at Cornell University
2004-2011 Research Associate at Cornell University
Supervisors: J.A. Burns and P.D. Nicholson

Processed and analyzed images of Saturn's faint rings obtained by the Imaging Sciences Subsystem of the Cassini spacecraft. Analyzed occultation and spectral data on Saturn's rings and atmosphere obtained by the Visual and Infrared Mapping Spectrometer onboard the Cassini spacecraft.

2002-2004 Research Fellow at Kavli Institute for Cosmological Physics
Supervisor: B. Winstein

Assembled and tested millimeter-wave polarimeters for CAPMAP, an effort to measure the polarization of the Cosmic Microwave Background. Analyzed calibration data of operational telescope. Worked on efforts to quantify systematic effects in microwave polarimeters. Helped develop techniques to calibrate and optimize large arrays of polarimeters.

1996-2001 Graduate Work at Princeton University
Supervisor: Suzanne Staggs

Assembled, tested and operated the PIQUE telescope, a prototype polarimeter for measuring the polarization of the Cosmic Microwave Background. Processed and analyzed data derived from this polarimeter.

First-Author Peer-Reviewed Publications

M.M. Hedman, C.M. Gosmeyer, P.D. Nicholson, C. Sotin, R.H. Brown, R.N. Clark, K.H. Baines, B.J. Buratti, M.R. Showalter. An observed correlation between plume activity and tidal stresses on Enceladus *Nature* 500:182-184

M.M. Hedman, P.D. Nicholson. “Kronoseismology: Using density waves in Saturn’s C ring to probe the planet’s interior. *The Astronomical Journal* 146:12 (2013) (2013)

M.M. Hedman, J.A. Burns, D.P. Hamilton, M.R. Showalter. “Of horseshoes and heliotropes: Dynamics of dust in the Encke Gap”. *Icarus* 233:252-276 (2013)

M.M. Hedman, P.D. Nicholson, J.N. Cuzzi, R.N. Clark, G. Filacchione, F. Capaccioni, M. Ciarniello. “Connections between spectra and structure in Saturn’s Main Rings based on Cassini VIMS data” *Icarus* 233:105-130 (2013)

M.M. Hedman, J.A. Burns, D.P. Hamilton, M.R. Showalter. “The three-dimensional structure of Saturn’s E ring” *Icarus* 217:322-328 (2012)

M.M. Hedman, P.D. Nicholson, M.R. Showalter, R.H. Brown, B.J. Buratti, R.N. Clark, K. Baines, C. Sotin. “The Christiansen Effect in Saturn’s narrow dusty rings and the spectral identification of clumps in the F ring” *Icarus* 215:695-711 (2011)

M.M. Hedman, J.A. Burns, M.W. Evans, M.S. Tiscareno, C.C. Porco. “Saturn’s curiously corrugated C ring” *Science* 332:708-711 (2011)

M.M. Hedman, J.A. Burt, J.A. Burns, M.S. Tiscareno. “The shape and dynamics of a heliotropic dusty ringlet in the Cassini Division” *Icarus* 210:284-297 (2010)

M.M. Hedman, N.J. Cooper, C.D. Murray, K. Buerle, M.W. Evans, M.S. Tiscareno, J.A. Burns. “Aegaeon (Saturn LIII) a G-ring object” *Icarus* 207:433-447 (2010)

M.M. Hedman, P.D. Nicholson, K. Baines, B. Buratti, C. Sotin, R.N. Clark, R.H. Brown, R. Frech, E. Marouf. “The architecture of the Cassini Division” *AJ* 139:228-251 (2010)

M.M. Hedman “Constraints on clade ages from fossil outgroups” *Paleobiology* 36:16-31 (2010)

M.M. Hedman, J.A. Burns, M.S. Tiscareno, C.C. Porco. “Organizing some very tenuous things: Resonant structures in Saturn’s faint rings” *Icarus* 202:260-279 (2009)

M.M. Hedman, P.D. Nicholson, M.R. Showalter, R.H. Brown, B.J. Buratti, R.N. Clark. “Spectral observations of the Enceladus plume with Cassini-VIMS” *ApJ* 693:1749-1762 (2009)

M.M. Hedman, C.D. Murray, N.J. Cooper, M.S. Tiscareno, K. Beurle, M. Evans, J.A. Burns. “Three tenuous rings/arcs for three tiny moons” *Icarus* 199:378-386 (2009)

M.M. Hedman, J.A. Burns, M.S. Tiscareno, C.C. Porco, G.H. Jones, E. Roussos, N. Krupp, C. Paranicas, S. Kempf. “The source of Saturn’s G ring” *Science* 317:653-657 (2007)

M.M. Hedman, P.D. Nicholson, H. Salo, B.D. Wallis, B.J. Buratti, K.H. Baines, R.H. Brown and R.N. Clark “Self-gravity wake structures in Saturn’s A ring revealed by Cassini-VIMS”, *AJ* 133:2624-2629 (2007)

M.M. Hedman, J.A. Burns, M.R. Showalter, C.C. Porco, P.D. Nicholson, A.S. Bosh, M.S. Tiscareno, R.H. Brown, B.J. Buratti, K. H. Baines, R.N. Clark “Saturn’s dynamic D ring” *Icarus* 188:89-107 (2007)

M.M. Hedman, D. Barkats, J.O. Gundersen, J.J. McMahon, S.T. Staggs and B. Winstein; “New limits on the polarized anisotropy of the Cosmic Microwave Background at subdegree angular scales”, *ApJ* 573:L73-L76 (2002)

M.M. Hedman, D. Barkats, J.O. Gundersen, S.T. Staggs and B. Winstein “A limit on the polarized anisotropy of the Cosmic Microwave Background at subdegree angular scales”, *ApJ* 548:L111-L114 (2001)

Other Peer-Reviewed Publications (Planetary Science)

J.D. Gougen, B.J. Buratti, R.H. Brown, R.N. Clark, P.D. Nicholson, M.M. Hedman, R.R. Howell, C. Sotin, D.P. Cruikshank, K.H. Baines, K.J. Lawrence, J.R. Spencer, D.G. Blackburn. “The temperature and width of an active fissure on Enceladus measured with Cassini VIMS during the 14 April 2012 South Pole flyover.” *Icarus* 226:1128-1137 (2013)

P.C. Thomas, J.A. Burns, M.M. Hedman, P. Helfenstein, S. Morrison, M.S. Tiscareno, J. Veverka. “The inner small satellites of Saturn: A variety of worlds” *Icarus* 226:999-1019 (2013)

M.S. Tiscareno, C.J. Mitchell, C.D. Murray, D. Di Nino, M.M. Hedman, J. Schmidt, J.A. Burns, J.N. Cuzzi, C.C. Porco, K. Beurle. “Observations of ejecta clouds produced by impacts onto Saturn’s rings” *Science* 340:460-464 (2013)

M.S. Tiscareno, M.M. Hedman, J.A. Burns, J. Castillo-Rogez. “Compositions and Origins of Outer Planet Systems: Insights from the Roche Critical Density.” *The Astrophysical Journal Letters* 765:L28 (2013)

M.S. Tiscareno, M.M. Hedman, J.A. Burns, J.W. Weiss, C.C. Porco. “Probing the inner boundaries of Saturn’s A ring with the Iapetus 1:0 nodal bending wave.” *Icarus* 224:201-208 (2013)

G. Filacchione, F. Capaccioni, M. Ciarniello, R.N. Clark, J.N. Cuzzi, P.D. Nicholson, D.P. Cruikshank, M.M. Hedman, B.J. Buratti, J.I. Lunine, L.A. Soderblom, F. Tosi, P. Cerroni, R.H. Brown, T.B. McCord, R. Jaumann, K. Stephan, K.H. Baines, E.

- Flamini "Saturn's icy satellites and rings investigated by Cassini-VIMS: III - Radial compositional variability". *Icarus* 220:1064-1096 (2012)
- R.S. French, M.R. Showalter, R. Sfair, C.A. Argüelles M. Pajuelo, P. Becerra, M.M. Hedman, P.D. Nicholson "The brightening of Saturn's F Ring". *Icarus* 219:181-189 (2012)
- S. Vahidinia, J.N. Cuzzi, M. Hedman, B. Draine, R.N. Clark, T. Roush, G. Filacchione, P.D. Nicholson, R.H. Brown, B. Buratti, C. Sotin "Saturn's F ring grains: Aggregates made of crystalline water ice". *Icarus* 215:682-694 (2011)
- D. Tamayo, J.A. Burns, D.P. Hamilton, M.M. Hedman "Finding the trigger to Iapetus' odd global albedo pattern: Dynamics of dust from Saturn's irregular satellites." *Icarus* 215:260-278 (2011)
- M.R. Showalter, M.M. Hedman, J.A. Burns. "The impact of comet Shoemaker-Levy 9 sends ripples through the main ring of Jupiter." *Science* 332:711-713 (2011)
- R. West, B. Knowles, E. Birath, S. Charnoz, D. di Nino, M.M. Hedman, P. Helfenstein, A. McEwen, J. Perry, C.C. Porco, J. Salmon, H. Throop, D. Wilson. "In-flight calibration of the Cassini Imaging Science Sub-system cameras" *PSS* 58:1574-1488 (2010)
- M.S. Tiscareno, J.A. Burns, M. Sremčević, K. Buerle, M.M. Hedman, N.J. Cooper, A.J. Milano, M.W. Evans, C.C. Porco, J.N. Spitale, J.W. Weiss. "Physical characteristics and non-keplerian orbital motion of "propeller" moons embedded in Saturn's rings. *ApJ* 718:L92-L96 (2010)
- M.S. Tiscareno, J.A. Burns, J.N. Cuzzi, M.M. Hedman. "Cassini imaging search rules out rings around Rhea" *GRL* 37:L14205 (2010)
- P.D. Nicholson, M.M. Hedman. "Self-gravity wake parameters in Saturn's A and B rings" *Icarus* 206:410-423 (2010)
- M.S. Tiscareno, R.P. Perrine, D.C. Richardson, M.M. Hedman, J.W. Weiss, C.C. Porco, J.A. Burns. "An analytic parameterization of self-gravity wakes in Saturn's rings, with application to occultations and propellers" *AJ* 139:492-503 (2010)
- E. D'Aversa, G. Bellucci, P.D. Nicholson, M.M. Hedman, R.H. Brown, M.R. Showalter, F. Altieri, F.G. Carrozzo, G. Filacchione, F. Tosi. "The spectrum of Saturn ring spoke from Cassini/VIMS" *GRL* 37:L01203 (2010)
- A. Bellucci, B. Sicardy, P. Drossart, P. Rannou, P.D. Nicholson, M.M. Hedman, K. Baines, B. Burrati "Titan solar occultation observed by Cassini/VIMS: Gas absorption and constraints on aerosol composition" *Icarus* 201:198-216 (2009)
- K.M. Pitman, B.J. Buratti, J.A. Mosher, J.M. Bauer, T.W. Momary, R.H. Brown, P.D. Nicholson, M.M. Hedman. "First high solar phase angle observations of Rhea using Cassini VIMS: Upper limits on water vapor and geologic activity. *ApJ* 680:L65-L68 (2008)

L.W. Esposito, B.K. Meinke, J.E. Colwell, P.D. Nicholson, M.M. Hedman. “Moonlets and clumps in Saturn’s F ring” *Icarus* 194:278-289 (2008)

M.S. Tiscareno, J.A. Burns, M.M. Hedman, C.C. Porco. “The population of propellers in Saturn’s A ring” *AJ* 135:1083-1091 (2008)

A. Coradini, F. Tosi, A.I. Gavrishin, F. Capaccioni, P. Cerroni, G. Filacchione, A. Adriani, R.H. Brown, G. Bellucci, V. Formisano, E. D’Aversa, J.I. Lunine, K.H. Baines, J.-P. Bibring, B.J. Buratti, R.N. Clark, D.P. Cruikshank, M. Combes, P. Drossart, R. Jaumann, Y. Langevin, D.L. Matson, T.B. McCord, V. Mennella, R.M. Nelson, P.D. Nicholson, B. Sicardy, C. Sotin, M.M. Hedman, G.B. Hansen, C.A. Hibbits, M. Showalter, C. Griffith, G. Strazzulla. “Identification of spectral units on Phoebe” *Icarus* 193:233-251 (2008)

P.D. Nicholson, M.M. Hedman, R.N. Clark, M.R. Showalter, D.P. Cruikshank, J.N. Cuzzi, G. Filacchione, F. Capaccioni, P. Cerroni, G.B. Hansen, B. Sicardy, P. Drossart, R.H. Brown, B.J. Buratti, K.H. Baines, A. Coradini. “A close look at Saturn’s rings with Cassini VIMS” *Icarus* 193:182-212 (2008)

M.S. Tiscareno, J.A. Burns, P.D. Nicholson, M.M. Hedman, C.C. Porco. “Cassini imaging of Saturn’s rings II. A wavelet technique for analysis of density waves and other radial structure in the rings” *Icarus* 189:14-34 (2007)

M.S. Tiscareno, P.D. Nicholson, J.A. Burns, M.M. Hedman, C.C. Porco. “Unraveling temporal variability in Saturn’s spiral density waves: Results and predictions. *ApJ* 651:L65-L68 (2006)

M.S. Tiscareno, J.A. Burns, M.M. Hedman, C.C. Porco, J.W. Weiss, L. Dones, D.C. Richardson and C.D. Murray; “100-metre-diameter moonlets in Saturn’s A ring from observations of ‘propeller’ structures”, *Nature* 440:648-650 (2006)

Other Peer-Reviewed Publications (Astrophysics and Cosmology)

P.N. Stewart, P.G. Tuthill, M.M. Hedman, P.D. Nicholson, J.P. Lloyd. “High-angular-resolution stellar imaging with occultations from the Cassini spacecraft - I. Observational technique.” *MNRAS* 433:2286-2293 (2013)

C. Bischoff, L. Hyatt, J.J. McMahon, G.W. Nixon, D. Samtleben, K.M. Smith, K. Vanderlinde, D. Barkats, P. Farese, T. Gaier, J.O. Gundersen, M.M. Hedman, S.T. Staggs and B. Winstein: “New measurements of fine-scale CMB polarization power spectra from CAPMAP at both 40 and 90 GHz”, *ApJ* 684:771-789 (2008)

D. Barkats, C. Bischoff, P. Farese, L. Fitzpatrick, T. Gaier, J.O. Gundersen, M.M. Hedman, L. Hyatt, J.J. McMahon, D. Samtleben, S.T. Staggs, K. Vanderlinde and B. Winstein; “First measurements of the polarization of the Cosmic Microwave Background Radiation at small angular scales from CAPMAP”, *ApJ* 619:L127-L130 (2005)

D. Barkats, C. Bischoff, P. Farese, T. Gaier, J.O. Gundersen, M.M. Hedman, L. Hyatt, J.J. McMahon, D. Samtleben, S.T. Staggs, E. Stefanescu, K. Vanderlinde and B. Winstein; “Cosmic Microwave Background polarimetry using correlation receivers with the PIQUE and CAPMAP Experiments”, *ApJS* 159:1-26 (2005)

W. Hu, M.M. Hedman and M. Zaldarriaga; “Benchmark parameters for CMB polarization experiments”, *Phys Rev D* 67:043004 (2003)

A. de Oliviera-Costa, M. Tegmark, M. Zaldarriaga, D. Barkats, J.O. Gundersen, M.M. Hedman, S.T. Staggs and B. Winstein; “First attempt at measuring the CMB cross-polarization”, *Phys Rev D* 67:023003 (2003)

S.T. Staggs, D. Barkats, J.O. Gundersen, C.P. Herzog, J.J. McMahon and B. Winstein. “Calibrating CMB Polarization Telescopes” in *AIP Conference Proceedings* 609:183-186 (2001).

Reviews and Popular Works

M.M. Hedman *The Age of Everything: How Science Explores the Past* University of Chicago Press (2007)

M.M. Hedman “Polarization of the Cosmic Microwave Background” *American Scientist* 93:236 (2005)

J.N. Cuzzi, J.A. Burns, S. Charnoz, R.N. Clark, J.E. Colwell, L. Dones, L.W. Esposito, G. Filacchione, R.G. French, M.M. Hedman, S. Kempf, E.A. Marouf, C.D. Murray, P.D. Nicholson, C.C. Porco, J. Schmidt, M.R. Showalter, L.J. Spiker, J.N. Spitale, R. Srama, M. Sremcevic, M.S. Tiscareno, J. Weiss. “An evolving view of Saturn’s dynamic rings” *Science* 327:1470-1475 (2010)

S. Charnoz, L. Dones, L.W. Esposito, P.R. Estrada, M.M. Hedman. “Origin and Evolution of Saturn’s Ring System”, in *Saturn from Cassini-Huygens* by M. Dougherty, L. Esposito, T. Krimigis (eds.), Springer (2009)

M. Horányi, J.A. Burns, M.M. Hedman, G.H. Jones, S. Kempf “Chapter 16: Diffuse Rings” in *Saturn from Cassini-Huygens* by M. Dougherty, L. Esposito, T. Krimigis (eds.), Springer (2009)

M.S. Tiscareno, M.M. Hedman. “Saturn’s colossal ring” *Nature* 461:1064-1065 (2009)

External Research Funding

2012-Present	Principal Investigator on Cassini Data Analysis Program Project “The Seasonal and Temporal Evolution of Saturn’s Faint Rings”
2011-2013	Principal Investigator on Cassini Data Analysis Program Project “Irregular and Time-Variable Structures in Saturn’s Main Rings”
2009-2012	Principal Investigator on Cassini Data Analysis Program Project “Structure and Dynamics of Saturn’s Faint Rings”
2009-2011	Co-Investigator on Cassini Data Analysis Program Project “Saturn Limb Studies: Helium Winds and Composition” PI P. Gierasch (Cornell)
2007-2009	Co-Investigator on Cassini Data Analysis Program Project “Dynamics and Evolution of Saturn’s Faint Rings” PI M.R. Showalter (SETI Institute)

Notable Community Service Activities

2011-2013	Committee Member of the Division for Dynamical Astronomy
2011	Helped organize the Rings 2011 Scientific Workshop This three-day scientific workshop had roughly 60 attendees from all over the world. Details of the workshop can be found at http://rings2011.astro.cornell.edu .

Education and Public Outreach Activities

2012

Instructor at Cornell University

Co-taught a 250-student introduction to astronomy course “Our Solar System” (ASTR1102) with S. Squyres. This involved preparing and giving roughly one half of the course lectures, as well as preparing exams and developing homework problems.

2011-2008

Guest Lectures at Cornell University

Composed and gave lectures on planetary rings for the following introductory astronomy courses: ASTR1102 “Our Solar System” in 2011 (Instructors S. Squyres, G. Sloan), 2010 (Instructors S. Squyres, J. Veverka) and 2009 (Instructor G. Sloan), ASTR2212 “The Solar System: Planets, Satellites and Rings” in 2010 (Instructor P. Gierasch) and 2009 (Instructor P.D. Nicholson) Also composed and gave lecture on dating methods for ASTR2202 “Our Home in the Solar System” in 2008 (Instructors J. Bell, D. Campbell)

2010,2007

CHARM Presentations

Composed and gave presentations describing recent results of the Cassini mission at a telecon attended both by members of the project and the public. Audio recordings and copies of the lecture slides are available at <http://saturn.jpl.nasa.gov/>

2012-2006

Mentoring Undergraduate Researchers at Cornell University

Advised undergraduate students conducting research for Dr. Nicholson and Dr. Burns as part of the Research Experience for Undergraduates, New York State Space Grant, and Cornell University Astronomy Department programs. The results of these students’ research has been presented at the Division of Planetary Science and the Division for Dynamical Astronomy meetings of the American Astronomical Society (Rehnberg et al. at the 2010 DPS meeting, Burt et al. and Freeman et al. at the 2010 DDA meeting, Burt et al. at the 2009 DPS meeting) and been included in at least one peer-reviewed research article (Hedman, Burt, Burns and Tiscareno 2010).

2004

Compton Lecture Series

Composed and gave a series of ten interdisciplinary public lectures on dating techniques. These lectures covered a wide range of topics, including Mayan historical texts, radiocarbon dating, gene sequence dating, and cosmology. Each talk was attended by about 100 people. A book based on these lectures, entitled *The Age of Everything*, has been published by the University of Chicago Press.

2002-2004

Mentoring Undergraduate Researchers at the University of Chicago

Advised undergraduate students conducting research for Dr. Winstein as part of the Research Experience for Undergraduates and University of Chicago research programs. The work performed by these students was instrumental in the success of the CAPMAP experiment’s measurement of the polarization of the cosmological background polarization.