

CURRICULUM VITAE*

Name: William Jeffrey Hughes
Born: 26 May 1950 at Bangor, Wales

Present Positions: Professor of Astronomy, Boston University
Associate Dean, Graduate School of Arts and Sciences

Nationality Status: British Subject, Permanent U.S. Resident
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Education

DATES	INSTITUTION	DEGREES AWARDED AND DATE
1960-67	Rydal School	
1968-71	Imperial College University of London	B.Sc., A.R.C.S., in Theoretical Physics, 1971
1971-74	Imperial College University of London	Ph.D., D.I.C., in Space Physics, 1974 (Thesis Supervisor: Prof. J.W. Dungey)

Professional Appointments

2010- Associate Dean, Graduate School of Arts and Sciences, Boston University.
2002-13 Director, Center for Integrated Space Weather Modeling.
1997-02 Chairman, Department of Astronomy, Boston University.
1990- Professor, Department of Astronomy, Boston University.
1987-97 Director, Center for Space Physics, Boston University.
1984-90 Associate Professor, Department of Astronomy, Boston University.
1984-85 Visiting Fellow, The Blackett Laboratory, Imperial College, London.
1978-84 Assistant Professor, Department of Astronomy, Boston University
1976-78 Research Assistant, The Blackett Laboratory, Imperial College, London.
1975-76 Visiting Scholar and Assistant Research Geophysicist, Institute of
Geophysics and Planetary Physics, UCLA.
1974-75 Visiting Fellow, Cooperative Institute for Research in the Environmental
Sciences, University of Colorado/NOAA.
1968 (8 months) Student Apprentice, General Electric Company, Hurst Research
Laboratories, Wembley, England.

* October 2013

Professional Societies

Member, American Geophysical Union
Fellow, Royal Astronomical Society
Member, Sigma Xi

Scholarships, Awards etc.

Pantfyedwyn Trust Scholar, (1963-1967)
Imperial College Exhibitioner, (1969-1971)
Senior Fulbright-Hayes Exchange Scholar, (1974-1976)

Professional Community Service

- Referee: Journal of Geophysical Research
Geophysical Research Letters
Journal of Geophysics
Planetary and Space Science
Journal of Atmospheric and Solar-Terrestrial Physics
Annales Geophysicae
Solar Physics
- Convenor: Symposia on “Hydromagnetic Wave Particle Interactions,” “The Physics of Pulsation Resonance Regions,” and “Characteristics and Structures of Pi2 Pulsations,” held at IAGA Scientific Assembly, Edinburgh, August, 1981.
- Chairman: International Sun Earth Explorer (ISEE) Working Group on Waves and Pulsations, 1980-1984.
- Member: Program Committee: Chapman Conference on “Waves in Magnetospheric Plasmas,” Hawaii, February, 1983.
- Guest-Editor: Geophysical Research Letters special issue on “on “Waves in Magnetospheric Plasmas,” August, 1983.
- Reporter: on “Hydromagnetic Waves in the Magnetosphere” for the U.S. National Report to XVIII IUGG General Assembly, Hamburg, August, 1983.
- Associate Editor: Geophysical Research Letters, 1983-1986.
- Convenor: Symposium on “ULF and VLF Waves” held at XXI URSI General Assembly, Florence, August 1984.

Chairman: IAGA Working Group III-1 on ULF Pulsations 1983-1987.

Convenor: Symposium on “Spatial Structure in ULF Wave Fields” held at IAGA Scientific Assembly, Exeter, England, August, 1989.

Member: Editorial Board of Planetary and Space Science. 1989-1992.

Secretary: Magnetospheric Physics (SM) Section, American Geophysical Union, 1990-1992.

Member: NSF Geospace Environment Modeling (GEM) Steering Committee. 1991-1998.
Chairman: 1994-1997.

Member: American Geophysical Union, Meetings Committee. 1992-1996.

Member: Program Committee: Chapman Conference on “Solar Wind Sources of Magnetospheric ULF Waves”, Williamsburg, VA, September 1992.

Member: National Research Council Committee on Geophysical and Environmental Data. 1992-1995.

Member: AGU Space Physics and Aeronomy (SPA) Section Awards Committee. 1992-1996. Chair: 1992-1994.

Member: Program Committee: COSPAR Symposium “Result of the Inter-Agency Solar Terrestrial Program (IASTP)”, Birmingham, UK, July 1996.

Member: American Geophysical Union, Budget and Finance Committee. 1996-2000.

Member: Organizing Committee: The Sixth US-Finnish Auroral Dynamics Workshop: Magnetospheric-Ionospheric Dynamics, Melbourne, Florida, 2-5 February 1997.

Associate Editor: Journal of Geophysical Research, 1997-2001

Vice-Chairman: University Space Research Association, Council of Institutions. 1998-1999; 2004-2006.

Chairman: University Space Research Association, Council of Institutions. 1999-2000, 2006-2008.

Coordinator: Geospace Environment Modeling Program (GEM), Magnetosphere-Ionosphere Coupling Campaign, 2000-2009

Member: American Institute of Physics, Physics Resources Policy Committee. 2002-2008

Member: University Space Research Association (USRA) Board of Trustees. 2004-2008

- Member: NCAR/High Altitude Observatory Vision Committee. 2007
- Moderator: American Institute of Physics Industrial Physics Forum, Boston, 2008
- Member: University Space Research Association (USRA) *ad hoc* Governance Committee, 2010-2011
- Chair: University Space Research Association (USRA) Nominating Committee. 2010-2013
- Member: Natural Science and Engineering Research Council of Canada Physics Evaluation Panel, 2011-2014; Chair, Astronomy and Space Physics Section, 2012-14
- Member: NASA Advisory Council Heliophysics Subcommittee, 2012-15

Boston University Committee Appointments and Service

- Director of Graduate Studies, Department of Astronomy, 1980-1984, 1985-1987.
- Member: University Research Advisory Committee, 1981-1984.
- Member: University Graduate Research Fellowship Committee, 1984-1989.
- Member: Faculty Council Research Activities Committee, 1986-1991. (Chairman, 1987-1989)
- Member: Faculty and University Councils, 1986-1990.
- Member: University Council Research Activities Committee, 1987-1991. (Chairman, 1987-1989)
- Member: College of Liberal Arts, Appointment, Promotion and Tenure Committee, 1987-1988; 1993-1994; 1996-1997.
- Director: Center for Space Physics, Graduate School of Arts and Sciences, 1987-97
- Chairman: University Reaccreditation Task Force on Research, 1988-1989.
- Member: College of Liberal Arts Executive Committee, 1988-1991.
- Chairman: Faculty Council Nomination Committee, 1989-1990
- Member: University Promotion and Tenure Committee, 1992-1993; 1995-1996.
- Chairman: Astronomy Graduate Admissions Committee, 1992-1995.

Member: University Fulbright Committee, 1993-1996.

Chairman: Department of Astronomy, College of Arts and Sciences, 1997-2002.

Chairman: College of Arts and Sciences Academic Conduct Committee, 2003-2004

Member: 7-year BA/MD Program Admissions Committee, 2007-2012.

Director of Undergraduate Studies, Department of Astronomy, 2008-2010

Associate Chairman: Department of Astronomy, 2009-2010

Member: University Task Force on Funding of Research Doctoral Programs, 2010-2011

Co-Chair: Responsible Conduct of Research Education Advisory Committee, 2010-

Member: University Council Student Life Committee, 2011-

List of Publications

- Hughes, W.J., The effect of two periodic conductivity anomalies on geomagnetic micropulsation measurements. *Geophys. J. R. Astr. Soc.* 31, 407, 1973.
- Hughes, W.J., The effect on micropulsations of a localized conductivity anomaly. *Geophys. J. R. Astr. Soc.*, 36, 641, 1974.
- Hughes, W.J., and Southwood, D.J., Effect of atmosphere and ionosphere on magnetospheric micropulsation signals. *Nature*, 248, 493, 1974.
- Hughes, W.J., On how the lithosphere, atmosphere and ionosphere affect magnetospheric micropulsations. Ph.D. Thesis, University of London, 1974.
- Hughes, W.J., The polarization of micropulsations and geoelectric structure. *Geophys. J. R. Astr. Soc.*, 38, 95, 1974.
- Hughes, W.J., The effect of the atmosphere and ionosphere on long period magnetospheric micropulsations. *Planet. Space Sci.*, 22, 1157, 1974.
- Hughes, W.J., and Wait, J.R., Effective wave tilt and surface impedance over a laterally inhomogeneous two-layer Earth. *Radio Science*, 10, 1001, 1975.
- Hughes, W.J., and Wait, J.R., Electromagnetic induction over a two-layer Earth with a sinusoidal over-burden. *Pure App. Geophys.*, 113, 591, 1975.
- Hughes, W.J., and Southwood, D.J., The screening of micropulsation signals by the atmosphere and ionosphere. *J. Geophys. Res.*, 81, 3234, 1976.
- Hughes, W.J., and Southwood, D.J., An illustration of modification of geomagnetic pulsation structure by the ionosphere. *J. Geophys. Res.*, 81, 3241, 1976.
- Hughes, W.J., McPherron, and Russell, C.T., Multiple satellite observations of pulsation resonance structure in the magnetosphere. *J. Geophys. Res.*, 82, 492, 1977.
- Arthur, C.W., McPherron, R.L., and Hughes, W.J., A statistical study of pc3 magnetic pulsations at synchronous orbit, ATS 6. *J. Geophys. Res.*, 82, 1149, 1977.
- Hughes, W.J., Comment on: "Hydromagnetic Waves in a Non-Uniform Plasma," by E. Kupfer. *J. Geophys.*, 43, 829, 1977.
- Hughes, W.J., McPherron, R.L., and Barfield, J.N., Geomagnetic pulsations observed simultaneously on three geostationary satellites. *J. Geophys. Res.*, 83, 1109, 1978.
- Newton, R.S., Southwood, D.J., and Hughes, W.J., Damping of geomagnetic pulsations by the ionosphere. *Planet. Space Sci.*, 26, 201, 1978.

- Hughes, W.J., Southwood, D.J., Mauk, B.H., McPherron, R. L., and Barfield, J.N., Alfvén waves generated by an inverted plasma energy distribution. *Nature*, 275, 43, 1978.
- Southwood, D.J., and Hughes, W.J., Source induced vertical components in geomagnetic pulsation signals. *Planet Space Sci.*, 26, 715, 1978.
- Hughes, W.J., McPherron, R. L., and Barfield, J.N., Mauk, B.H., A compressional pc4 pulsation observed by three satellites in geostationary orbit near local midnight. *Planet Space Sci.*, 27, 821, 1979.
- Hughes, W.J., Multiple satellite studies of ULF waves. In *Proceedings of the International Workshop on Selected Topics of the Magnetospheric Physics*; Japanese IMS Committee, Tokyo, 1979.
- Mier-Jedrezejowicz, W.A.C. and Hughes, W.J., Phase skipping in pulsation signals. *J. Geophys. Res.*, 85, 6888, 1980.
- Hughes, W.J. Multisatellite observations of geomagnetic pulsations. *J. Geomag. Geoelec.*, 32, Suppl. II, SII41, 1980.
- Singer, H.J., Hughes, W.J., and Russell, C.T., Standing Alfvén waves observed by ISEE 1 and 2: Radial extent and harmonic. *J. Geophys. Res.*, 87, 3519, 1982.
- Nopper, R.W., Hughes, W.J., MacLennan, C.G., and McPherron, R.L., Impulse excited pulsations during the July 27, 1977 event. *J. Geophys. Res.*, 87, 5911, 1982.
- Hughes, W.J., Pulsation research during the I.M.S. *Rev. Geophys. Space Phys.*, 20, 641, 1982.
- Cowley, S.W.H., and Hughes, W.J., Observations of an I.M.F. effect in the Y magnetic field component at geostationary orbit. *Planet. Space Sci.*, 31, 73, 1983.
- Southwood, D.J., and Hughes, W.J., Theory of hydromagnetic waves in the magnetosphere. *Space Sci. Rev.*, 35, 301, 1983.
- Hughes, W.J., Hydromagnetic waves in the magnetosphere. *Rev. Geophys. Space Phys.*, 21, 508, 1983.
- Hughes, W.J., Waves in magnetospheric plasmas: Editorial. *Geophys. Res. Lett.* 10, 601, 1983.
- Singer, H.J., Hughes, W.J., Fougere, P.F., and Knecht, D. J., The localization of pi2 pulsations: Ground satellite observations. *J. Geophys. Res.*, 88, 7029, 1983.
- Hughes, W.J., Hydromagnetic waves in the magnetosphere, in *Solar-Terrestrial Physics: Principles and Theoretical Foundations* (R.L. Carovillano and J.M. Forbes, Eds.). D. Reidel, Dordrecht, 1983.

- Lester, M., Hughes, W.J., and Singer, H.J., Polarization patterns of pi2 magnetic pulsations and the substorm current wedge. *J. Geophys. Res.*, 88, 7958, 1983.
- Hughes, W.J., and Grard, R.J.L., A second-harmonic geomagnetic field line resonance at the inner edge of the plasma sheet; GEOS 1 ISEE 1 and ISEE 2 observations. *J. Geophys. Res.*, 89, 2755, 1984.
- Sutcliffe, P.R., Walker, A.D.M., Smits, D.P., Hughes, W.J., and Goertz, C., Magnetic signatures during the magnetospheric substorm of 27 July 1979. *S. Afr. J. Phys.*, 7, 7, 1984.
- Lester, M., Hughes, W.J., and Singer, H.J., Longitudinal structure in pi2 pulsations and the substorm current wedge. *J. Geophys. Res.*, 89, 5489, 1984.
- Takahashi, K., McPherron, R.L., and Hughes, W.J., Multispacecraft observations of azimuthally polarized pc 3-4 magnetic pulsations, *J. Geophys. Res.*, 89, 6758, 1984.
- Singer, H.J., Hughes, W.J., Russell, C.T., and Grard, R.J.L., Magnetospheric pulsations observed by ISSE 1 and 2 satellites. *Proc. Conf. Achievements of the IMS*, p. 619, ESA SP-217, Paris 1984.
- Lester, M., Hughes, W.J., and Singer, H.J., Pi2 pulsations and the substorm current wedge: ground observations. *Proc. Conf. Achievements of the IMS*, p. 673, ESA SP-217, Paris 1984.
- Singer, H.J., Knecht, D.J., Hughes, W.J., Gelpi, C., and Lester, M., Ground satellite observations of substorm related pi2 pulsations and current systems. *Proc. Conf. Achievements of the IMS*, p. 679, ESA SP-217, Paris 1984.
- Southwood, D.J., and Hughes, W.J., Concerning the structure of pi2 pulsations. *J. Geophys. Res.*, 90, 386, 1985.
- Daly, R.A., and Hughes, W.J., The effect of hydromagnetic waves on the shape of the plasmapause boundary. *J. Geophys. Res.*, 90, 537, 1985.
- Hughes, W.J., and Singer, H.J., Midlatitude pi2 pulsations, geosynchronous substorm onset signatures and auroral zone currents on 22 March 1979: CDAW-6 *J Geophys. Res.*, 90, 1297, 1985.
- Gelpi, C., Hughes, W.J., Singer, H.J., and Lester, M., Midlatitudes pi2 polarization pattern and synchronous orbit magnetic activity. *J. Geophys. Res.*, 90, 6451, 1985.
- Hughes, W.J. Smits, D.P., Cattell, C.A., and Russell, C.T., Multisatellite investigations of substorm onsets. *Adv. Space Res.*, 5, 159, 1985.

- Singer, H.J., Hughes, W.J., Gelpi, C., and Ledley, B.G., Magnetic disturbances in the vicinity of synchronous orbit and the substorm current wedge: a case study. *J. Geophys. Res.*, *90*, 9583, 1985.
- Gelpi, C., Hughes, W.J., and Singer, H.J., Longitudinal phase and polarization characteristics in mid latitude $\pi/2$ pulsations. *J. Geophys. Res.*, *90*, 9905, 1985.
- Smits, D.P., Hughes, W.J., Cattell, C.A., and Russell, C.T., Observations of field-aligned currents, waves and electric fields at substorm onset. *J. Geophys. Res.*, *91*, 121, 1986.
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- Cowley, S.W.H., and Hughes, W.J., A definitive test of the Primdahl-Spangselev hypotheses concerning the nature of the solar wind-magnetosphere interactions. *Planet. Space Sci.*, *34*, 745, 1986.
- Hughes, W.J., and Cowley, S.W.H., Observation of IMF associated magnetic field perturbations in the GSM X component at geostationary orbit, in *Solar Wind-Magnetosphere Coupling*, (Y. Kamide and J.A. Slavin, Eds.) p. 691, D. Reidel, Dordrecht, 1986.
- Murphy, N., Slavin, J.A., Baker, D.N., and Hughes, W.J., Enhancements of energetic ions associated with travelling compression regions in the deep geomagnetic tail. *J. Geophys. Res.*, *92*, 64, 1987.
- Gelpi, C., Singer, H.J., and Hughes, W.J., A comparison of magnetic signatures and DMSP auroral images at substorm onset: 3 case studies. *J. Geophys. Res.*, *92*, 2447, 1987.
- Gledhill, J.A., Dore, I.S., Goertz, C.K., Haggard, R., Hughes, W.J., Scourfield, M.W.J., Smits, D.P., Stoker, P.H., Sutcliffe, P.R., Wakerley, P.A., and Walker, A.D.M., A magnetospheric substorm observed at Sanae, Antarctica, *J. Geophys. Res.*, *92*, 2461, 1987.
- Hughes, W.J., and Sibeck, D.G., On the three-dimensional structure of plasmoids, *Geophys. Res. Lett.*, *14*, 636, 1987.
- Crowley, G., Hughes, W.J., and Jones, T.B., Observational evidence of cavity modes in the Earth's magnetosphere, *J. Geophys. Res.*, *92*, 12,233, 1987.
- Hughes, W.J., Multisatellite observations of field-aligned current systems, *Adv. Space Res.*, *V8*, (9) 321, 1988.
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- Lester, M., Singer, H.J., Smits, D.P., and Hughes, W.J., Pi2 pulsations and the substorm current wedge -- low latitude polarization, *J. Geophys. Res.*, *94*, 17133, 1989.
- Kivelson, M.G., and Hughes, W.J., On the threshold for triggering substorms, *Planet. Sci.*, *38*, 211, 1990.
- Moldwin, M.B., and Hughes, W.J., A 2 ½ dimensional magnetic field model of plasmoids, in *The Physics of Magnetic Flux Ropes*, (C.T. Russell, E.R. Priest, and L.C. Lee, Eds.), AGU Mono. Ser., v 58, p. 663, American Geophysical Union, Washington, DC, 1990.
- Hughes, W.J., Waves on the magnetopause and their signature on the ground, in *Report of the GEM Workshop on Ionospheric Signatures of Cusp, Magnetopause and Boundary Layer Processes*, (T.J. Rosenberg, Ed.), p. 33, Univ. Maryland, College Park, 1990.
- Mendillo, M., Baumgardner, J., Flynn, B., and Hughes, W.J., The extended sodium nebula of Jupiter, *Nature*, *348*, 312, 1990.
- Ludlow, G.R., Hughes, J.W., Engebretson, M.J., Slavin, J.A., Sugirura, M., and Singer, H.J., Ion cyclotron waves near L=4.6: a ground-satellite correlation study, *J. Geophys. Res.*, *96*, 1451, 1991.
- Moldwin, M.B., and Hughes, W.J., Plasmoids as magnetic flux ropes, *J. Geophys. Res.*, *96*, 14051, 1991.
- Moldwin, M.B., and Hughes, W.J., Multisatellite observations of plasmoids: IMP 8 and ISEE 3, *Geophys. Res. Lett.*, *19*, 1081, 1992.
- Basinka, E.W., Burke, W.J., Maynard, N.C., Hughes, W.J., Winningham, J.D., and Hanson, W.B., Small scale electrodynamic of the cusp with northward interplanetary magnetic field, *J. Geophys. Res.*, *97*, 6369, 1992.
- Moldwin, M.B., and Hughes, W.J., Plasmoid observations in the distant plasma sheet boundary layer, *Geophys. Res. Lett.*, *19*, 1911, 1992.
- Paranicas, C., Hughes, W.J., Singer, H.J., and Anderson, R.R., Banded electrostatic emissions observed by the CRRES plasma wave experiment, *J. Geophys. Res.*, *97*, 13889, 1992.
- Moldwin, M.B., and Hughes, W.J., On the formation and evolution of plasmoids: a survey of ISEE 3 Geotail data, *J. Geophys. Res.*, *97*, 19259, 1992.

- Singer, H.J., Hughes, W.J., and Anderson, R.R., Advances in substorm physics from CRRES, *Adv. Space Res.*, 13, (4) 203, 1993.
- Moldwin, M.B., and Hughes, W.J., Geomagnetic substorm association of plasmoids, *J. Geophys. Res.*, 98, V81, 1993.
- Ludlow, G.R., and Hughes, W.J., The ion cyclotron group delay for source regions near the plasmopause, *J. Geophys. Res.*, 98, 7561, 1993.
- Hughes, W.J., (Editor), *Outstanding Questions in Geotail and Substorm Physics*, Report of the GEM Workshop on the Physics of the Tail and Substorms. Boston University, May 1993.
- Moldwin, M.B., and Hughes, W.J., Observations of earthward and tailward propagating flux rope plasmoids: Expanding the plasmoid model of geomagnetic substorms, *J. Geophys. Res.*, 99, 183, 1994.
- Shodhan, S., Crooker, N.U., Hughes, W.J., and Siscoe, G. L., Heliospheric Current Sheet Inclinations predicted from source surface maps, *J. Geophys. Res.*, 99, 2531, 1994.
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- Fraser, B.J., Singer, H.J., Hughes, W.J., Anderson, R.R., and Wygant, J.R., Electromagnetic ion cyclotron harmonic waves near the plasmopause, *Adv. Space Res.*, 5, 255-258, 1994
- Hughes, W.J., Magnetospheric ULF Waves: A tutorial with a historical perspective, in *Solar Wind Sources of ULF Waves*, (M.J. Engbretson, K. Takahashi, and M. Scholer, Eds.), AGU Geophys. Mono. Ser., v81, p. 1, Am. Geophys. Un., 1994.
- Basinka, E.M., Burke, W.J., Maynard, N.C., Hughes, W.J., Knudsen, D.J., and Slavin, J.A., Electric and magnetic fluctuations at high latitudes in the dayside ionosphere during southward IMF, in *Solar Wind Sources of ULF Waves*, (M.J. Engbretson, K. Takahashi, and M. Scholer, Eds.), AGU Geophys. Mono. Ser., v81, p. 387, Am. Geophys. Un., 1994.
- Rasinkangas, Mursula, K., Kremser, G., Singer, H.J., Fraser, B.J., Korth, A., and Hughes, W.J., in *Solar Wind Sources of ULF Waves*, (M.J. Engbretson, K. Takahashi, and M. Scholer, Eds.), AGU Geophys. Mono. Ser., v81, p. 417, Am. Geophys. Un., 1994.
- Hughes, W.J., (Editor), *Strategies for the Tail and Substorm Campaign*, Report of the GEM Workshop on the Physics of the Tail and Substorms. Boston University, April 1994.
- Hughes, W.J., ULF Waves in the Cusp and Cleft: Signatures of Boundary Layer Processes, in *Physical Signatures of Magnetospheric Boundary Layer Processes*, (J.A. Holtet, and A. Egeland, Eds.) p. 349, Kluwer Acad. Pub., Dordrecht, 1994.

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- Hughes, W.J., The Magnetopause, Magnetotail, and Magnetic Reconnection, in *Introduction to Space Physics* (M.G. Kivelson and C.T. Russel, Eds.), pp. 227-287, Camb. Univ. Press., New York, 1995.
- Hughes, W.J., Engebretson, M.J., and Zesta. E., Ground Observations of Transient Cusp Phenomena: Initial Results from MACCS, in *Physics of the Magnetopause*, (P. Song, B.U.O. Sonnerup, and M.F. Thomsen, Eds.) AGU Geophys. Mono. Ser., v90, p. 427, Am. Geophys. Un., Washington DC. 1995.
- Engebretson, M.J., Hughes, W.J., Alford, J.L., Zesta, E., Cahill, L.J., Arnoldy, R.L., and Reeves, G.D., MACCS Observations of the Spatial Extent of Broadband ULF Magnetic Pulsations at Cusp/Cleft Latitudes, *J. Geophys. Res.*, *100*, 19371, 1995.
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- Fraser, B.J., Singer, H.J., Hughes, W.J., Wygant, J.R., Anderson, R.R., and Hu, Y.D., CRRES Pointing vector observations of electromagnetic ion cyclotron waves near the plasmopause, *J. Geophys. Res.*, *101*, 15331, 1996.

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- Hughes, W.J., and Engebretson, M.J., MACCS: Magnetometer Array for Cusp and Cleft Studies, in *Satellite Ground Based Coordination Sourcebook*, (M. Lockwood, H.J. Opgenoorth, M.N. Wild, and R. Stamper, Eds.) p.119, ESA-SP-1198, European Space Agency, Noordwijk, The Netherlands, 1997.
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