Curriculum Vitae

Alan P. Marscher

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Education Ph.D., Astronomy, University of Virginia, 1977
M.S., Astronomy, University of Virginia, 1974
B.S., Engineering Science, Cornell University, 1973

Positions Held

1992-present	Professor of Astronomy, College of Arts and Sciences, Boston University
2017-2019	Associate Chair, Department of Astronomy, Boston University
2015-2016	Acting Chair, Department of Astronomy, Boston University
2011-2015	Director, Institute for Astrophysical Research, Boston University
2013-2014	Associate Director, Core Curriculum, College of Arts and Sciences, Boston University
2003-2007	Director, Center for Excellence in Teaching, Boston University
1999-2003	Associate Dean, College of Arts and Sciences, Boston University
1990-91	Visiting Scientist, Smithsonian Astrophysical Observatory
1987-1997	Chair, Department of Astronomy, Boston University
1987-1992	Associate Professor of Astronomy, Boston University
1986-1987	Chairman *ad interim*, Department of Astronomy, Boston University
1981-1987	Assistant Professor of Astronomy, Boston University
1978-1981	Postgraduate Research Physicist, U. of California, San Diego
1977-1978	NAS-NRC Postdoctoral Research Associate at NASA Goddard Space Flight Center
1976-1977	Junior Research Associate (Thesis Student), National Radio Astronomy Observatory, Charlottesville, Virginia
1976-1977	Instructor of Physics, Mary Baldwin College, Staunton, Virginia
1975	Summer Student, National Radio Astronomy Observatory

Honors

Co-recipient of 2021 Royal Astronomical Society Group Achievement Award, awarded to the Event Horizon Telescope Collaboration
Co-recipient of 2020 Breakthrough Prize in Fundamental Physics awarded to the Event Horizon Telescope Collaboration
Co-recipient of 2020 Rossi Prize awarded to the Event Horizon Telescope Collaboration by the High Energy Astrophysics Division of the American Astronomical Society
Co-recipient of Nelson P. Jackson Aerospace Award awarded to the Event Horizon Telescope Collaboration by the National Space Club & Foundation
Co-recipient of 2019 inaugural Diamond Achievement Award bestowed by the National Science Foundation to the Event Horizon Telescope Collaboration
Recipient of 2014 Metcalf Award for Excellence in Teaching, Boston University
Recipient of 1998 Gitner Award for Distinguished Teaching, College of Arts and Sciences, Boston University
Distinguished Member of the National Society of Collegiate Scholars (inducted in 2003)
Polytropos Award, Core Curriculum, College of Arts & Sciences, Boston University (2003)
Member of Phi Beta Kappa (inducted in 1999)
Vice President, LYCHNOS Graduate Honor Society, University of Virginia

Ph.D. Thesis "Effects of Nonuniform Structure in Compact Synchrotron Sources"

Ph.D. Advisor Dr. Robert L. Brown, National Radio Astronomy Observatory
Professional Societies American Astronomical Society
International Astronomical Union
American Association for the Advancement of Science

Major Professional Committees

Chair, Technical Working Group on Blazars and Radiogalaxies, Imaging X-ray Polarimetry Explorer (IXPE) mission, 2018–present
Chair, Imaging Group of the Event Horizon Telescope collaboration, 2018–2019
Member, Long Baseline Observatory Advisory Council, 2017–2018
Chair, NASA Fermi Gamma-ray Space Telescope Users Group, 2009–2013
Member, Electorate Nominating Committee, Section on Astronomy, American Association for the Advancement of Science, 2007–2010
Member, external oversight committee for the VERITAS γ-ray Cherenkov telescope, 2003–2007
Member, NASA Gamma-ray Large Area Space Telescope Users Committee, 2003–2007
Member, Committee of Visitors, Division of Astronomical Sciences, National Science Foundation, 2005
Member, *ad hoc* panel to map the future of VLBI research in the US, 2003
Member, Panel on Radio and Submillimeter Astronomy, Decadal Astronomy and Astrophysics Survey, National Academy of Sciences, 1998–2000 & 2004-2005
AUI Visiting Committee for the National Radio Astronomy Observatory, 1992–95 (chair 1994-5)
National Science Foundation Advisory Committee on Astronomical Sciences, 1988-92
National Radio Astronomy Observatory Users Committee, 1984–87, 1990–93
ARISE Space VLBI Advisory Committee, 1998–1999
NASA Compton Gamma Ray Observatory Users Committee, 1995–98
Secretary-Treasurer of High Energy Astrophysics Division of the American Astronomical Society, 1997–99
Chairman of Nominating Committee, High Energy Astrophysics Division of the American Astronomical Society, 1988
At-large member of Very Long Baseline Interferometry telescope consortium, 1984–88
Various panels reviewing funding proposals for NASA and NSF
Various scientific organizing committees for astronomical conferences
Member of panel reviewing proposals to use the Very Long Baseline Interferometer Network, 1982–89
Member of panel reviewing proposals to use the Coordinated Millimeter-Wave VLBI Array, 1995–2000
Member of board of Associated Universities for Research in Astronomy, 1993–1994

Major University Committees

College of Arts & Sciences (CAS) Academic Policy Committee, 2017-2020
CAS Natural Sciences Curriculum Committee, 1984–86, 2009–12, 2016-17
Provost's Teaching Award Committee, 2015-16
Provost's Advisory Board on Distance Education, 2007-08
Advisory Board, Center for Excellence in Teaching, 2000-2003
Core Curriculum science development committee, 1987–89, 91–92 (chair, 1988–89,91–92)
College of Liberal Arts (CLA) Academic Policy Committee, 1988-90 (chairman, 1988-89)
Integrated Core Curriculum development committee, 1985–88
CLA Petitions Committee, 1983–84

Courses Taught

CC 105 Evolution of the Universe and of the Earth (Core Curriculum)
AS 101 The Solar System (for non-science majors)
AS 102 The Astronomical Universe (for non-science majors)
AS 105 Survey of the Universe (for non-science majors)
AS 109 Cosmology (for non-science majors)
AS 312 Stellar and Galactic Astronomy (for science majors)
AS 413 Extragalactic Astrophysics & Cosmology (for science majors)
AS 503 Galactic Astronomy (graduate level)
AS 701 Introduction to Astrophysics (graduate level)
AS 706 Radiative Processes and Spectroscopy (graduate level)
AS 711 Cosmic Mechanics & Dynamics (graduate level)
AS 712 Radiative Processes in Astrophysics (graduate level)
AS 755 Radio Astrophysics (graduate level)
AS 757 High Energy Astrophysics (graduate level)
AS 793 Graduate seminar on quasars and active galactic nuclei
PH 101/102 Introductory Physics (non-calculus, at Mary Baldwin College)

Supervision of Theses and Dissertations

Apostolos Mastichiadis (Ph.D., 1985) (joint supervision with K. Brecher)
Sridhar Subramanian (M.A., 1986)
James C. Kilian (M.A., 1986)
Linda Shore (M.A., 1986)
Ruth A. Daly (Ph.D., 1987)
Steven D. Bloom (Ph.D., 1994)
Yun Fei Zhang (Ph.D., 1994)
Matthew L. Lister (Ph.D., 1998)
Markos Georganopoulos (Ph.D., 1999)
Andrei Sokolov (Ph.D., 2004)
Ritaban Chatterjee (Ph.D., 2009)
Francesca D'Arcangelo (Ph.D., 2009)
Monica Bruecker Young (Ph.D., 2010) (Joint supervision with M. Elvis)
Michael Malmrose (Ph.D., 2016)
Nicholas MacDonald (Ph.D., 2016)
Mason Keck (Ph.D., 2019)

Narrative Summary of Academic Activities at Boston University

I have taught a number of Astronomy courses for non-majors, majors, and graduate students while at Boston University, both in Astronomy and in the Core Curriculum of the College of Arts and Sciences. The Core course was CC 105, The Evolution of the Universe and the Earth, I was the primary architect of the course, but a number of other professors contributed substantially. I was the course coordinator (lead faculty member) of the course from 1989 to 2002, save for two sabbatical years, and again in 2013 and 2014. I have written a textbook for the course entitled *From Nothing to Everything: The Story of the Universe*, which is available as an e-book, with free downloads, for AS109 and CC105 students, as well as the public. It was also used in an introductory astronomy course at the University of Michigan by Prof. Philip Hughes and at Williams College by Prof. Karen Kwitter. I compose pop songs for AS109 and CC105 and perform them in my lectures. The textbook and recorded versions of songs are available at the website www.bu.edu/blazars.

Narrative Summary of Current Research

I and my research group study the extremely energetic plasma jets that emanate from a class of active galactic nuclei called "blazars" (radio-bright quasars and BL Lacertae objects, whose brightness tends to be highly variable and whose continuum spectra are non-thermal). The general consensus of the field is that ultra-massive (over a billion solar masses) black holes residing at the center of many galaxies power blazars as they accrete matter from their surroundings. The black holes swallow most of the gas and dust, but expel a small fraction in winds and jets along the rotation axes, at flow speeds very close to the speed of light. Such relativistic motions create illusions of faster-than-light speeds and beams the radiation emitted such that observers viewing the jet almost along the axis measure a very high brightness that varies on timescales as short as hours. The work of my group focuses on monitoring the changing brightness at radio, infrared, X-ray, and gamma-ray frequencies as well as the evolving radio-frequency structure of the jet on sub-milliarcsecond scales. Telescopes used currently include the international Event Horizon Telescope (I am part of the EHT Collaboration that imaged the emission surrounding the black hole in the galaxy M87) and Global Millimeter VLBI Array (GMVA), the Very Long Baseline Array (VLBA) and Very Large Array of the National Radio Astronomy Observatory, NASA's Hubble Space Telescope, Spitzer Space Telescope (infrared), Chandra X-ray Observatory, Rossi X-Ray Timing Explorer (RXTE), Swift, NuSTAR, NICER, and XMM-Newton (X-ray) satellite observatories, Fermi Gamma-ray Space Telescope, and the Boston University Perkins Telescope and Lowell Discovery Telescope.

In addition to this observational program, I lead my group in theoretical studies focused on the radiative processes and gas dynamics that occur in the jets of blazars. The main goal is to provide models that can be used to interpret images, polarization, and multifrequency monitoring observations of blazars in the hopes of figuring out the physics of jets: what produces them (what evidence can we obtain that it is really an accreting supermassive black hole?), what focuses and accelerates their flows to speeds very close to the velocity of light (twisting magnetic fields, gas pressure, or radiation pressure?), what accelerates the electrons to ultrarelativistic energies (shock waves - transverse to the jet axis or oblique? reconnection of magnetic fields? turbulence?), and what processes affect the emission (bends in the jet, accelerations in the flow, instabilities, precession?).

An extensive website on the research of my group is located at http://www.bu.edu/blazars. The site includes background information, many images of jets, and some animations of sequences of images and light curves as well as artists' conceptions of the activity at the heart of a quasar.

Narrative Summary of Administrative Experience at Boston University

From 2017 to the present time, I have been Associate Chair of the Astronomy Department. In 2015-16, I served as Acting Chair of the department. From 2011 to 2015, I was the Director of the Institute for Astrophysical Research . The IAR promotes research, education, and public outreach in astrophysics at BU. It also administers external funding grants in astrophysics as well as Boston University's partnership with Lowell Observatory for use of the 1.8-meter-diameter Perkins Telescope outside Flagstaff, Arizona.

From September 2013 to December 2014, I served as an associate director of the Core Curriculum in the College of Arts and Sciences, Boston University. In this capacity, I was lead instructor of the physical science course CC105, and advised the Core director on current and future directions of the program.

Between 2003 and 2007, I was the Director of the Center for Excellence & Innovation in Teaching (CEIT) at Boston University. The CEIT operates a variety of programs designed to assist instructors who wish, for example, to improve their classroom performance, modernize their teaching techniques (e.g., through use of the web), or administer their courses more effectively.

From January 1999 to June 2003 I was an Associate Dean in the College of Arts and Sciences at Boston University (half-time), with primary responsibility for faculty issues. Among my main duties were design and oversight of the College web site, running of orientation programs for new graduate teaching fellows

and new "adjunct" faculty, coordination of continuing programs of language instruction for international graduate teaching fellows, identifying physical problems in classrooms that need to be fixed and acting as a liaison between instructors and Media Group, formation of a panel to determine recipients of College teaching awards, compilation of grading statistics in Arts and Sciences courses, and providing guidance to departmental chairs and to faculty.

I served as chair of the Department of Astronomy from 1986 to 1997. During that time, the size of the academic faculty grew from 8 to 15 members, while that of the research faculty increased from 1 to 7. The department thrived in all areas (as it continues to do), especially in grant and contract activity and the teaching of undergraduate students.

BIBLIOGRAPHY

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Books

Marscher, A.P., DePaor, D.G., Mohr, S.C., and Whitaker, J.S. *From Nothing to Everything: The Evolution of the Universe and the Earth* (Boston: Pearson Custom Publishing) (2002). Textbook for Boston University Core Curriculum physical science course.

Marscher, A.P. *From Nothing to Everything: The Story of the Universe*, 2019, published as an e-book, distributed *gratis* to students and the public. The book is available for free download at http://www.bu.edu/blazars/textbook.html.

Refereed Journal Papers

1. Bergh, S. van den, Marscher, A.P., and Terzian, Y. "An Optical Atlas of Galactic Supernova Remnants," 1973, *Astrophysical Journal Supplement Series*, **26**, 19-36 (no. 227).

2. Marscher, A.P., and Brown, R.L. "An Interpretation of the Radio Outbursts of Cygnus X-3," 1975, *Astrophysical Journal*, **200**, 719-726.

3. Goldstein, S.J., Marscher, A.P., and Rood, R.T. "On the Aggregate Flux of Weak Point Sources at 1400 MHz," 1976, *Astrophysical Journal*, **210**, 321-325.

4. Brown, R.L., and Marscher, A.P. "Energetic Secondary Electrons in Dense Interstellar Clouds," 1977, *Astrophysical Journal*, **212**, 659-663.

5. Marscher, A.P. "Effects of Nonuniform Structure on the Derived Physical Parameters of Compact Synchrotron Sources," 1977, *Astrophysical Journal*, **216**, 244-256.

6. Marscher, A.P. "Structure of Radio Sources with Remarkably Flat Spectra: PKS 0735+178," 1977, *Astronomical Journal*, **82**, 781-784.

7. Marscher, A.P. "Relativistic Blast-Wave Model for Superlight Motion in Compact Double Radio Sources," 1978, *Astrophysical Journal*, **219**, 392-399.

8. Brown, R.L., and Marscher, A.P. "Are Supernovae Radio Sources? A Search for Radio Emission from Young Supernova Remnants," 1978, *Astrophysical Journal*, **220**, 467-473.

9. Marscher, A.P., and Brown, R.L. "Origin and Evolution of the Radio Emission from Immediate Post-Outburst Supernovae," 1978, *Astrophysical Journal*, **220**, 474-483.

10. Marscher, A.P., and Brown, R.L. "Energetic Secondary Electrons and the Nonthermal Galactic Radio Background: A Probe of the Magnetic Field in Interstellar Clouds," 1978, *Astrophysical Journal*, **221**, 588-597.

11. Marscher, A.P. "Relativistic Blast-Wave Model for the Rapid Flux Variations of AO 0235+164 and Other Compact Sources," 1978, *Astrophysical Journal*, **224**, 816-825.

12. Marscher, A.P. "Interaction between Emission Line Filaments and Highly Energetic Explosions in QSOs," 1978, *Astrophysical Journal*, **225**, 725-731.

13. Marscher, A.P., and Weaver, R.P. "On the Formation and Confinement of Dense Clouds in QSOs and Active Galactic Nuclei," 1979, *Astrophysical Journal*, **227**, 705-709.

14. Marscher, A.P. "Absorption Models for Low-Frequency Variability in Compact Radio Sources," 1979, *Astrophysical Journal*, **228**, 27-33.

15. Marscher, A.P., Marshall, F.E., Mushotzky, R.F., Dent, W.A., Balonek, T.J., and Hartman, R.F. "Search for X-Ray Emission from Bursting Radio Sources," 1979, *Astrophysical Journal*, **233**, 498-503.

16. Shaffer, D.B.. and Marscher, A.P. "VLBI Observations of Galactic Nuclei at 18 cm," 1979, *Astrophysical Journal (Letters)*, **233**, L105-L108.

17. Marscher, A.P. "Relativistic Jets and the Continuum Emission in QSOs," 1980, *Astrophysical Journal*, **235**, 386-391.

18. Marscher, A.P., and Scott, J.S. "Superluminal Motion in Compact Radio Sources," 1980, *Publ. Astron. Soc. Pacific*, **92**, 127-133.

19. Marscher, A.P., and Shaffer, D.B. "VLBI Observations at 18 and 2.8 cm: 0133+47, 0735+178, OH471, OQ172, 1633+38, and NRAO 667," 1980, *Astronomical Journal*, **85**, 668-672.

20. Marscher, A.P. "Spontaneous Formation of Knots in Relativistic Flows: A Model for Variability in Compact Synchrotron Sources," 1980, *Astrophysical Journal*, **239**, 296-304.

21. Marscher, A.P., Vestrand, W.T., and Scott, J.S. "Neutrino, Gamma-Ray, Electron, and Positron Production in an Ultrarelativistic Plasma," 1980, *Astrophysical Journal*, **241**, 1166-1174.

22. Rothschild, R.E., Baity, W.A., Marscher, A.P., and Wheaton, W.A. "Nonthermal Hard X-Ray Emission from the Nucleus of NGC 1275," 1981, *Astrophysical Journal (Letters)*, **243**, L9-L12.

23. Vestrand, W.T., Scott, J.S., Marscher, A.P., and Christiansen, W.A. "Effects of Gamma-Ray, Neutrino, and Particle Production on the Energetics and Dynamics of Compact Extragalactic Radio Sources," 1981, *Astrophysical Journal*, **245**, 811-817.

24. Marscher, A.P., and Broderick, J.J. "Distance-Independent Evidence for Relativistic Motion in the Quasar NRAO 140," 1981, *Astrophysical Journal (Letters)*, **247**, L49-L52.

25. Marscher, A.P., and Broderick, J.J. "X-Ray and VLBI Radio Observations of the Quasars NRAO 140 and NRAO 530," 1981, *Astrophysical Journal*, **249**, 406-414.

26. Marscher, A.P., and Burbidge, E.M. "Rotating Compact Radio Sources and Angular Momentum Transfer from the Nucleus to Outlying Gas in Active Galaxies," 1982, *Astrophysical Letters,* **22**, 83-87.

27. Marscher, A.P., and Broderick, J.J. "Apparent Superluminal Motion in the Quasar NRAO 140," 1982, *Astrophysical Journal (Letters)*, **255**, L11-L15.

28. Junkkarinen, V.T., Marscher, A.P., and Burbidge, E.M. "Einstein X-Ray Observations of QSOs with Absorption-Line Systems," 1982, *Astronomical Journal*, **87**, 845-848.

29. Marscher, A.P. "Accurate Formula for the Self-Compton X-Ray Flux Density from a Uniform, Spherical, Compact Radio Source," 1983, *Astrophysical Journal*, **264**, 296-297.

30. Marscher, A.P., and Broderick, J.J. "VLBI Observations of the Quasars CTD20 (0234+285), OJ248 (0827+243), and 4C19.44 (1354+195), and the Millimeter-X-Ray Connection," 1983, *Astronomical Journal*, **88**, 759-763.

31. Marscher, A.P., Brecher, K., Wheaton, W.A., Ling, J.C., Mahoney, W.A., and Jacobson, A.S. "Search for 511 KeV Electron- Positron Annihilation Radiation from Mildly Active Galaxies Using the HEAO-3 Gamma-Ray Spectrometer," 1984, *Astrophysical Journal (Letters)*, **281**, 566-569.

32. Marscher, A.P., and Broderick, J.J. "Multifrequency Radio VLBI Observations of the Superluminal, Low-Frequency Variable Quasar NRAO 140." 1985, *Astrophysical Journal*, **290**, 735-741.

33. Marscher, A.P., and Gear, W.K. "Models for High-Frequency Radio Outbursts in Extragalactic Sources with Application to the Early 1983 Millimeter to Infrared Flare of 3C273," 1985, *Astrophysical Journal*, **298**, 114-127.

34. Mastichiadis, A., Marscher, A.P., and Brecher, K. "Electron-Positron Pair Production by Ultrarelativistic Electrons in a Soft Photon Field," 1986, *Astrophysical Journal*, **300**, 178-189.

35. Mastichiadis, A., Brecher, K., and Marscher, A.P. "Electromagnetic Cascades in the Magnetosphere of a Very Young Pulsar: A Model for the Positron Production near the Galactic Center," 1987, *Astrophysical Journal*, **314**, 88-94.

36. Shaffer, D.B., Marscher, A.P., Marcaide, J.M., and Romney, J.D. "Multi-Epoch VLBI Observations of 4C39.25: Superluminal Motion amid Stationary Structure," 1987, *Astrophysical Journal (Letters)*, **314**, L1-L5.

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38. Marscher, A.P., Shaffer, D.B., Booth, R.S., and Geldzahler, B.J. "Multifrequency VLBI Observations of 4C39.25: A Superluminal Source without a Well-Defined Core," 1987, *Astrophysical Journal (Letters)*, **319**, L69-L72.

39. Daly, R.A., and Marscher, A.P. "The Gas Dynamics of Compact Relativistic Jets," 1988, *Astrophysical Journal*, **334**, 539-551.

40. Marscher, A.P. "Contemporaneous X-Ray and VLBI Radio Observations of the Quasar NRAO 140," 1988, *Astrophysical Journal*, **334**, 552-559.

41. McHardy, I.M., Marscher, A.P., Gear, W.K., Muxlow, T., Lehto, H.J., and Abraham, R.G. "VLBI, MERLIN, and VLA Observations of the Blazar 1156+295," 1990, *Monthly Notices of the Royal Astronomical Society*, **246**, 305-314.

42. Bloom, S.D., and Marscher, A.P. "Comparison of VLBI Radio Core and X-ray Flux Densities of Extragalactic Radio Sources," 1991, *Astrophysical Journal*, **366**, 16-21.

43. Marscher, A.P., Zhang, Y.F., Shaffer, D.B., Aller, H.D., and Aller, M.F. "Multifrequency VLA, VLBI, and Single-Dish Observations of the Quasar 4C 39.25," 1991, *Astrophysical Journal*, **371**, 491-500.

44. Marscher, A.P., Bania, T.M., and Wang, Z. "Detection of Local Interstellar CO Absorption toward BL Lacertae," 1991, *Astrophysical Journal (Letters)*, **371**, L77-L80.

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48. Bloom, S.D., Marscher, A.P., Gear, W.K., Teräsranta, H., Valtaoja, E., Aller, H.D., and Aller, M.F. "Radio, Millimeter-Submillimeter, and Infrared Spectra of Flat-Spectrum Extragalactic Radio Sources," 1994, *Astronomical Journal*, **108**, 398–404.

49. Zhang, Y.F., Marscher, A.P., Aller, H.D., Aller, M.F., Teräsranta, H., and Valtaoja, E. "Radio and X-Ray Observations of the γ-Ray Bright Quasar PKS 0528+134," 1994, *Astrophysical Journal*, **432**, 91–102.

50. Marscher, A.P., and Stone, A.L. "Simulations of Variations of Absorption Line Profiles in Clumpy Molecular Clouds," 1994, *Astrophysical Journal*, **433**, 705–711.

51. Gómez, J.L., Alberdi, A., Marcaide, J.M., Marscher, A.P., and Travis, J.P. "Synchrotron Emission from Bent Shocked Relativistic Jets," 1994, *Astronomy & Astrophysics*, **292**, 33–44.

52. Edelson, R., ..., Marscher, A.P. (37th author), *et al.* "Multi-Wavelength Monitoring of the BL Lacertae Object PKS 2155−304. IV. Multi-Wavelength Analysis," 1995, *Astrophysical Journal*, **438**, 120.

53. Gómez, J.L., Martí, J.M., Marscher, A.P., Ibáñez, J.M., and Marcaide, J.M. "Parsec-Scale Synchrotron Emission from Hydrodynamic Relativistic Jets in Active Galactic Nuclei," 1995, *Astrophysical Journal (Letters)*, **449**, L19–L21 + insert plates L2 and L3.

54. Macomb, D., ..., Marscher, A.P., et al. "Multi-Wavelength Observations of Mkn 421 during a TeV/X-Ray Flare," 1995, *Astrophysical Journal (Letters)*, **449**, L99–L103.

55. Moore, E.M., and Marscher, A.P. "Observational Probes of the Small Scale Structure of Molecular Clouds," 1995, *Astrophysical Journal*, **452**, 671–679.

56. Marscher, A.P. "Probes of the Inner Jets of Blazars," 1995, *Proc. Nat. Acad. Sci.*, **92**, 11439–11441.

57. Paglione, T.M., Marscher, A.P., Jackson, J.M., and Bertsch, D.L. "Diffuse Gamma-Ray Emission from the Starburst Galaxy NGC 253," 1996, *Astrophysical Journal*, **460**, 295–302.

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