

CURRICULUM VITAE

Name: William Michael Irvine

Born: August 31, 1936; Los Angeles, California, USA

Educational Background:

1957 Pomona College	B.A. (summa cum laude)
1959 Harvard University	M.A. (Physics)
1961 Harvard University	Ph.D. (Physics)

Professional Employment:

1961-62	Leiden University, Holland	NATO Post-doc. Fellow
1962-66	Harvard Coll./Smith. Ast. Obs.	Research Fellow/Physicist
1964-66	Harvard University	Lecturer
1966-68	University of Massachusetts	Associate Professor
1966-79	University of Massachusetts	Chair, Astronomy Program
1966-78	Five College Astronomy Dept.	Chairman
1969-2006	University of Massachusetts	Professor
1973-74	Onsala Space Obs. (Sweden)	Visiting Professor
1977 (summer)	Kanazawa Inst. Tech. (Japan)	Visiting Professor
1979-81	Onsala Space Obs. (Sweden)	Acting Scientific Director
1985-1995	Five College Radio Astron. Obs.	Director
1990 (winter)	National Astron. Obs. (Japan)	Visiting Professor
2004 (fall)	INAOE (Mexico)	Visiting Scientist
2006-present	University of Massachusetts	Professor Emeritus

Research Specialization: Interstellar Medium, Planetary Science, Astrobiology

Selected Scholarly Activities:

COSPAR (Commissions F, B.1)

American Astronomical Society (Heinemann Prize Committee, 1994-97; Nominating Committee, 1989-92, Chairman, 1990-91; Division for Planetary Sciences, Chairman, 1973-74, DPS Committee, 1972-75, 1978-81).

Harlow Shapley Visiting Lecturer, AAS, 1975-76, 1978-79.

American Geophysical Union.

Royal Astronomical Society

International Astronomical Union (Commissions 15, 16, 34, 51: Vice-President 2006-2009; President 2009- 2012; Past President 2012-2015; Division F: Executive Committee 2012- 2015).

International Scientific Radio Union.

International Society for the Study of the Origin of Life (Councillor, 2008-2011).
 Committee on Astmospheric Radiative Transfer, Radiation Commiss., IAMAP, 1973-81.
 Icarus Editorial Board, 1975-76, Associate Editor, 1976-91.
 Northeast Radio Observatory Corp., Board of Trustees, 1966-79 and
 1983-2010, Vice-Chairman, 1970-74.
 Herzberg Inst. Astrophys. Review Comm., NRC Canada, 1984.
 NASA Workshops on Exobiology from Earth Orbit, Co-Chairman, 1984-86.
 Comm. Planetary Biology and Chemical Evolution, NAS-NRC, 1985-88.
 International Halley Watch, Radio Science Discipline Specialist, 1982-89.
 Arecibo Advisory Board and Visiting Comm., 1985-88, Chairman, 1987-88.
 Principal Investigator, various grants from NSF and NASA, 1966-2014.
 Co-Investigator, USSR Phobos Mission, 1988-91.
 Origin Life Evol. Biosphere, Editorial Board, 1990-96.
 NASA Exobiology Disc. Working Group, 1990-98
 NASA IRTF Mgmt. Oper. Working Group, 1991-94.
 NASA Exobiology Panel, 1995-98
 NSF LExEn Panel, 1997
 NRAO, 12m Telescope Proposal Review Panel, 1997-99
 NASA Planetary Astronomy Panel, 2000
 NASA Keck Time Allocation Committee, 2001-2003
 Intern. Space Science Inst. (Switzerland), Working Group on Prebiotic Chemistry, 2001-
 2003
 NASA Exobiology Panel, 2007
 Bioastronomy 2007 (IAU Comm. 51), Chair, SOC
 IAU Symp. 251, 2008, member, SOC
 "Origins 2011" (IAU Comm. 51 & ISSOL), member, SOC
 Member, European Astrobiology Institute, Working Group on Historical, Philosophical,
 Societal & Ethical Issues in Astrobiology, 2019-present

Honors:

NSF Pre-doctoral Fellow in Physics, Harvard University, 1958-61.
 NATO Post-doctoral Fellow in Astronomy, Leiden University, Holland, 1961-62.
 International Research and Exchanges Board Fellow, Chalmers University of Technology
 (Sweden), 1973-74.
 University Medal (University of Helsinki), 1988.
 Faculty Fellowship (Univ. Mass.; 3 awarded annually), 1990-91.

Dissertations Supervised (University of Massachusetts):

Kawata, Yoshiyuki, Ph.D. 1974, "Models of Saturn's Rings which Satisfy the Optical
 and Infrared Observations".
 Esposito, Larry W., Ph.D. 1978, "Light Scattering from Saturn's Rings Calculated by a
 Markov Chain Formalism".
 Thompson, William T., Ph.D. 1982, "The 'Swarm' Model for the Azimuthal Brightness
 Variations in Saturn's Ring A".

Madden, Suzanne C., Ph.D. 1990, "A Multi-Transition Study of the Cyclic Molecule Cyclopropenylidene (C₃H₂) in the Galaxy".
Minh, Young Chol, Ph.D. 1990, "Radio Observations of Several Interstellar Molecules".
McGonagle, Douglas, Ph.D. 1995, "Nitrogen Chemistry in the Interstellar Medium".
Dickens, James E., Ph.D. 1998, "Probing Chemical Evolution in Molecular Clouds with Millimeter-wave Observations"

A. Scientific Articles

1. "Sedimentation and Diffusion Studies on Hyaluronic Acid", Brunish, R., Vangerov, M., and Irvine, W.M., Fed. Proc., 15, No. 735 (1956).
2. "Local Irregularities in a Universe Satisfying the Cosmological Principle", Ph.D. Thesis, Harvard University (1961).
3. "General Report on Radiative Transfer in Planets: Scattering in Model Planetary Atmospheres", van de Hulst, H.C. and Irvine, W.M., Mem. Soc. Roy. Sc. Liege, 7, 78 (1963).
4. "Electrodynamics in a Rotating System of Reference", Irvine, W.M., Physica, 30, 1160 (1964).
5. "Effect of High Voltage on Spectral Sensitivity for Two Photomultipliers", Irvine, W.M., Pikoos, C., and Charon, J., Ap. J., 140, 1629 (1964).
6. "The Asymmetry of the Scattering Diagram of a Spherical Particle", Irvine, W.M., Bull. Astron. Inst. Netherlands, 17, 176 (1964).
7. "The Formation of Absorption Bands and the Distribution of Photon Optical Paths in a Scattering Atmosphere", Irvine, W.M., Bull. Astron. Inst. Netherlands, 17, 266 (1964).
8. "Local Irregularities in an Expanding Universe", Irvine, W.M., Annals of Physics, 32, 322 (1965).
9. "Light Scattering by Spherical Particles: Radiation Pressure, Asymmetry Factor and Extinction Cross Section", Irvine, W.M., J. Opt. Soc. Amer., 55, 16 (1965).
10. "Multiple Scattering by Large Particles", Irvine, W.M., Ap. J., 142, 1563 (1965).
11. "The Distribution of Photon Optical Paths in a Scattering Atmosphere", Irvine, W.M., Ap. J., 144, 1140 (1966).
12. "The Shadowing Effect in Diffuse Reflection", Irvine, W.M., J. Geophys. Res., 71, 2931 (1966).
13. "A Note on the Formation of Irregularities in a Freidman Universe", Irvine, W.M., Mem. Soc. Roy. Sc. Liege, 15, 29 (1967).

14. "Infrared Optical Characteristics of Ice Spheres", Irvine, W.M., Smithsonian Contrib. Astrophys., 11, 367 (1967).
15. "Absorption Bands and Photon Optical Paths in a Nonconservative Scattering Atmosphere", Irvine, W.M., Ap. J., 147, 1193 (1967).
16. "Multicolor Photoelectric Photometry of the Brighter Planets. I. Program and Procedure", Young, A.T. and Irvine, W.M., Astron. J., 72, 945 (1967).
17. "Infrared Optical Properties of Water and Ice Spheres", Irvine, W.M. and Pollack, J.B., Icarus, 8, 324 (1968).
18. "Diffuse Reflection and Transmission by Cloud and Dust Layers", Irvine, W.M., J. Quant. Spectrosc. Radiat. Transf., 8, 471 (1968).
19. "Multiple Scattering by Large Particles. II. Optically Thick Layers", Irvine, W.M., Ap. J., 152, 823 (1968).
20. "Multicolor Photoelectric Photometry of the Brighter Planets. II. Observations from Le Houga Observatory", Irvine, W.M., Simon, T., Menzel, D., Charon, J., Lecomte, G., Griboval, P., and Young, A., Astron. J., 73, 251 (1968).
21. "Monochromatic Phase Curves and Albedos for Venus", Irvine W.M., J. Atmos. Sci., 25, 610 (1968).
22. "An Evaluation of Romanova's Method in the Theory of Radiative Transfer", Irvine, W.M., in The Atmospheres of Venus and Mars, ed. J.C. Brandt and M.B. McElroy, Gordon & Breach, p. 57 (1968).
23. "Multicolor Photoelectric Photometry of the Brighter Planets. III. Observations from Boyden Observatory", Irvine, W.M., Simon, T., Menzel, D., Pikoos, C., and Young, A., Astron. J., 73, 807 (1968).
24. "Computation of Synthetic Spectra for a Semi-Infinite Atmosphere", Uesugi, A. and Irvine, W.M., J. Atmos. Sci., 26, 973 (1969).
25. "Multiple Scattering in a Plane-Parallel Atmosphere. I. Successive Scattering in a Semi-Infinite Medium", Uesugi, A. and Irvine, W.M., Ap. J., 159, 127 (1970).
26. "Multiple Scattering in a Plane-Parallel Atmosphere. II. Curves of Growth for Reflection Spectra", Uesugi, A. and Irvine, W.M., Ap. J., 161, 243 (1970).
27. "The Eddington Approximation for Planetary Atmospheres", Kawata, Y. and Irvine, W.M., Ap. J., 160, 787 (1970).

28. "Observations of Atmospheric Extinction from 0.135 to 1.06 Microns", Irvine, W.M. and Peterson, F., J. Atmos. Sci., 27, 72 (1970).
29. "Variations in the Color of Jupiter", Hopkins, N. and Irvine, W.M., Planetary Atmospheres, IAU Symp. 40, ed. C. Sagan, D. Reidel, Holland, pp. 349-352 (1971).
30. "Longitudinal Variations, the Opposition Effect, and Monochromatic Albedos for Mars", Irvine, W.M., Higdon, J.C., and Ehrlich, S., Planetary Atmospheres, IAU Symp. 40, ed. C. Sagan, D. Reidel, Holland, pp. 141-155 (1971).
31. "Formation of Absorption Spectra by Diffuse Reflection from a Semi-Infinite Planetary Atmosphere", Kawata, Y., Irvine, W.M., and Uesugi, A., J. Quant. Spec. Radiat. Transf., 11, 797 (1971).
32. "Monochromatic Albedos for the Disk of Saturn", Irvine, W.M. and Lane, A., Icarus, 15, 18 (1971).
33. "Multicolor Photoelectric Photometry of Uranus", Appleby, J. and Irvine, W.M., Astron. J., 76, 617 (1971).
34. "Monochromatic and Radiometric Albedos for Mars and Venus", Irvine, W.M., in Eizika Luny i Planet, ed. Martynov and Bronshten, Izd. Nauka, Moscow, 326ff (1972).
35. "Path Length Distribution of Photons Diffusely Reflected from a Semi-Infinite Atmosphere", Appleby, J. and Irvine, W.M., Ap. J., 183, 337 (1973).
36. "Photometric Properties of Saturn's Rings", Irvine, W.M. and Lane, A., Icarus, 18, 171 (1973).
37. "Monochromatic Phase Curves and Albedos for the Lunar Disk", Lane, A. and Irvine, W.M., Astron. J., 78, 267 (1973).
38. "Radio Detection of Interstellar CH", Rydbeck, O.E.H., Ellder, J., and Irvine, W.M., Nature, 246, 466 (1973).
39. "Solving Multiple Scattering Problems in Planetary Atmospheres", Irvine, W.M. and Lenoble, J., UCLA International Conference on Radiation and Remote Probing of the Atmosphere, ed. J. Kuriyan, Western Periodicals, Hollywood, p. 1 (1974). Invited Review.
40. "Model of Saturn's Rings that Satisfies the Observed Phase Curve for Optical Scattering", Irvine, W.M., The Rings of Saturn, NASA SP-343, 17 (1974). Invited Review.

41. “Models of Saturn’s Rings which Satisfy the Optical Observations”, Kawata, Y. and Irvine, W.M., *Exploration of the Planetary System, IAU Symp. 65*, ed. Wosczyk and D.Iwaniszewska, D. Reidel, p. 441 (1974).
42. “Observations of CH Microwave Line Ratios for Galactic Sources”, Rydbeck, O.E.H., Ellder, J., Irvine, W.M., Sume, A., and Hjalmarson, Å., *Astron. Astrophys.*, 33, 315 (1974).
43. “The CH Radical: Radio Astronomical Determination of Ground State Transition Frequencies”, Rydbeck, O.E.H., Ellder, J., Irvine, W.M., Sume, A., and Hjalmarson, Å., *Astron. Astrophys.*, 34, 479 (1974).
44. “A Search for Microwave Emission from CH in Comet Kohoutek”, Rydbeck, O.E.H., Ellder, J., Irvine, W.M., Ronnang, B., Godfrey, P., Fourikis, N., and Sinclair, M., *Icarus*, 23, 595 (1974).
45. “Multiple Scattering in Planetary Atmospheres”, Irvine, W.M., *Icarus*, 25, 175 (1975). *Invited Review.*
46. “Thermal Emission from a Multiple Scattering Model of Saturn’s Rings”, Kawata, Y. and Irvine, W.M., *Icarus*, 24, 472 (1975).
47. “Radio Observations of Interstellar CH”, Rydbeck, O.E.H., Kollberg, E., Hjalmarson, Å., Sume, A., Ellder, J., and Irvine, W.M., *Ap. J. Suppl.*, 31, 333 (1976).
48. “Multiple Scattering in Planetary Atmospheres”, Irvine, W.M., *Optical Propagation in the Atmosphere*, AGARD, NATO CP-183 (1976). *Invited Review.*
49. “Azimuthal Brightness Variations of Saturn’s Rings”, Lumme, K. and Irvine, W.M., *Ap. J. (Lett.)*, 204, L55 (1976).
50. “Search for Radiation from the $^2\Pi_{1/2}$, $J=5/2$ State of Interstellar CH”, Sume, A., Rydbeck, O.E.H., Kollberg, E., and Irvine, W.M., *Astron. Astrophys.*, 51, 155 (1976).
51. “Photometry of Saturn’s Rings”, Lumme, K. and Irvine, W.M., *Astron. J.*, 81, 865 (1976).
52. “CH Radio Emission Towards the W49 Region”, Sume, A. and Irvine, W.M., *Astron. Astrophys.*, 60, 337 (1977).
53. “CO Emission from Supernova Remnants”, Wannier, P., Irvine, W.M., Scoville, N.Z., and Predmore, C.R., *Ap. J.*, 216, 320 (1977).

54. “Radio Observations of CH Towards Various Galactic Objects”, Sume, A. and Irvine, W.M., *Astron. Astrophys.*, 60, 345 (1977).
55. “Azimuthal Brightness of Saturn’s Rings. II. Observations at an Intermediate Tilt Angle”, Lumme, K., Esposito, L.W., Irvine, W.M., and Baum, W.A., *Ap. J. (Lett.)*, 216, L123 (1977).
56. “Azimuthal Brightness of Saturn’s Rings”, Esposito, L.W., Irvine, W.M., Lumme, K., and Baum, W.A., in *Symp. Planetary Atmospheres*, ed. A. Wallace-Jones, Royal Society of Canada, Ottawa, p. 89ff (1978).
57. “Millimeter Wavelength Spectroscopy of Trace Atmospheric Constituents from the Five College Radio Astronomy Observatory”, Huguenin, G.R. and Irvine, W.M., *Fourth Joint Conf. Sensing Environmental Pollutants*, Amer. Chem. Soc., Washington, D.C., p. 245ff (1978).
58. “Low Tilt Angle Photometry and the Thickness of Saturn’s Rings”, Lumme, K. and Irvine, W.M., *Astron. Astrophys.*, 71, 123 (1979).
59. “Azimuthal Brightness Variations of Saturn’s Rings. III. Observations at Tilt Angle $B \cong 11.6^\circ$ ”, Lumme, K., Irvine, W.M., Martin, L.J., and Baum, W.A., *Ap. J. (Lett.)*, 229, L109 (1979).
60. “A Search for Millimeter-Wave Emission from HCN, CO, and CH₃CN in Comet Bradfield (1978c)”, Schloerb, P., Irvine, W.M., and Robinson, S., *Icarus*, 38, 392 (1979).
61. “A Model for the Azimuthal Brightness Variations in Saturn’s Rings”, Lumme, K. and Irvine, W.M., *Nature*, 282, 695 (1979).
62. “Observations of SO in Dark and Molecular Clouds”, Rydbeck, O.E.H., Irvine, W.M., Hjalmarsen, Å., Ellder, J., Rydbeck, G., and Kollberg, E., *Ap. J. (Lett.)*, 235, L171 (1980).
63. “Spectra of the 10-0₁ Transition of Sulfur Monoxide in Interstellar Clouds”, Rydbeck, O.E.H., Hjalmarsen, Å., Ellder, J., Rydbeck, G., Kollberg, E., and Irvine, W.M., in *Interstellar Molecules*, ed. B. Andrew, D. Reidel, Holland, 71-76 (1980).
64. “Thermal History, Chemical Composition, and Relationship of Comets to the Origin of Life”, Irvine, W.M., Leschine, S.B., and Schloerb, F.P., *Nature*, 283, 748 (1980).
65. “Interstellar C₃N: Detection in Taurus Dark Clouds”, Friberg, P., Hjalmarsen, Å., Irvine, W.M., and Guelin, M., *Ap. J. (Lett.)*, 241, L99 (1980).

66. "On Methyl Formate, Methane, and Deuterated Ammonia in Orion A", Ellder, J., Friberg, P., Hjalmarsen, Å., Höglund, B., Irvine, W.M., Johansson, L.E.B., Olofsson, H., Rydbeck, G., Rydbeck, O.E.H., and Guélin, M., *Ap. J. (Lett.)*, **242**, L93 (1980).
67. "Observations of CO in the Stratosphere of Venus via the J=1-0 Rotational Transition", Schloerb, F.P., Robinson, S.E., and Irvine, W.M., *Icarus*, **43**, 121 (1980).
68. "A Search for Interstellar Imadazole and Cyanoforn", Irvine, W.M., Ellder, J., Hjalmarsen, Å., Kollberg, E., Rydbeck, O.E.H., Sörenson, G.O., and Bak, B., *Astron. Astrophys.*, **97**, 192 (1981).
69. "Molecules in Interstellar Clouds", Irvine, W.M., Hjalmarsen, Å., and Rydbeck, O.E.H., in *Origin of Life*, ed. Y. Wolman, D. Reidel (Holland), pp. 11-18 (1981).
70. "Comets and the Origin of Life", Irvine, W.M., Leschine, S.B., and Schloerb, F.P. in *Origin of Life*, ed. Y. Wolman, D. Reidel (Holland), pp. 27-32 (1981).
71. "A Search for Millimeter-Wave Emission from HCN and Other Molecules in Comet Bradfield (1979I)", Ekelund, L., Irvine, W.M., Schloerb, F.P., and Robinson, S., *Icarus*, **47**, 431 (1981).
72. "A Search for the 1.35cm Line of H₂O in Comets Kohler (1977 XIV) and Meier (1978 XXI)", Crovisier, J., Despois, D., Gerard, E., Irvine, W.M., Schloerb, F.P., and Robinson, S., *Astron. Astrophys.*, **97**, 195 (1981).
73. "Saturn's Rings: Azimuthal Variations, Phase Curves, and Radial Profiles in Four Colors", Thompson, W.T., Lumme, K., Irvine, W.M., Baum, W.A., and Esposito, L.W., *Icarus*, **46**, 187 (1981).
74. "The Increasing Chemical Complexity of the Taurus Dark Clouds: Detection of CH₃CCH and C₄H", Irvine, W.M., Höglund, B., Friberg, P., Askne, J., and Ellder, J., *Ap. J. (Lett.)*, **248**, L113 (1981).
75. "Determination of the HNC to HCN Abundance Ratio in Giant Molecular Clouds", Goldsmith, P.F., Langer, W.D., Ellder, J., Irvine, W.M., and Kollberg, E., *Ap. J.*, **249**, 524 (1981).
76. "Radiative Transfer in the Surfaces of Atmosphereless Bodies. III. Interpretation of Lunar Photometry", Lumme, K. and Irvine, W.M., *Astron. J.*, **87**, 1076 (1982).
77. "Comets, Interstellar Molecules, and the Origin of Life", Irvine, W.M. and Hjalmarsen, Å., in *Cosmochemistry and the Origin of Life*, ed. C. Ponnamperna, D. Reidel, Holland, pp. 113-142 (1983). Invited Review.

78. "Observations of Sulfur Dioxide in the Kleinmann-Low Nebula", Schloerb, F.P., Höglund, B., Friberg, P., Hjalmarsen, Å., and Irvine, W.M., *Ap. J.*, 264, 161(1983).
79. "Theoretical Interpretation of the Ground-Based Photometry of Saturn's B Ring", Lumme, K., Irvine, W.M., and Esposito, L.W., *Icarus*, 53, 174 (1983).
80. "The [HCO⁺]/[HOC⁺] Abundance Ratio in Molecular Clouds", Woods, R.C., Gudeman, C.S., Dickman, R.L., Goldsmith, P.F., Huguenin, G.R., Irvine, W.M., Hjalmarsen, Å., Nyman, L.A., and Olofsson, H., *Ap. J.*, 270, 583, (1983).
81. "The Chemical Composition of the Pre-Solar Nebula", Irvine, W.M., in *Cometary Exploration III*, ed. T. Gombosi, Central Res. Inst. Physics, Hungarian Acad. Sci., pp. 83-93 (1983).
82. "Observations of SO₂ and HCS⁺ in Cold Molecular Clouds", Irvine, W.M., Good, J.C., and Schloerb, F.P., *Astron. Astrophys.*, 127, L10 (1983).
83. "Methyl Acetylene as a Temperature Probe in Molecular Clouds", Askne, J., Höglund, B., Hjalmarsen, Å., and Irvine, W.M., *Astron. Astrophys.*, 130, 311 (1984).
84. "Spectral Scan of Orion KL and IRC+10216 from 73 to 91 GHz", Johansson, L.E.B., Andersson, C., Ellder, J., Friberg, P., Hjalmarsen, Å., Höglund, B., Irvine, W.M., Olofsson, H., and Rydbeck, G., *Astron. Astrophys.*, 130, 227 (1984).
85. "A Model Containing "Blobs" for the A Ring of Saturn", Thompson, W., Van Blerkom, D., and Irvine, W.M., in *Les Anneaux des Saturn*, *IAU Colloq. 75*, ed. A. Brahic, Cepadues-Ed., France, pp. 93-98 (1984).
86. "Azimuthal Variations in Saturn's A Ring", Lumme, K. and Irvine, W.M., in *Les Anneaux des Saturn*, *IAU Colloq. 75*, ed. A. Brahic, Cepadues-Ed., France, pp. 87-91 (1984).
87. "The Detection of Interstellar Methylcyanoacetylene", Broten, N.W., MacLeod, J.M., Avery, L.W., Irvine, W.M., Höglund, B., and Hjalmarsen, Å., *Ap. J. (Lett.)*, 276, L25 (1984).
88. "The Chemical Composition of Interstellar Molecular Clouds", Irvine, W.M. and Hjalmarsen, Å., *Origin of Life*, 14, 15 (1984). *Invited Review.*
89. "Cyanide and Isocyanide Abundances in the Cold, Dark Cloud TMC-1", Irvine, W.M. and Schloerb, F.P., *Ap. J.*, 282, 516 (1984).

90. "A New Interstellar Molecule: Tricarbon Monoxide", Matthews, H.E., Irvine, W.M., Friberg, P., Brown, R.D., and Godfrey, P.D., *Nature*, **310**, 125 (1984).
91. "Hydrogen Cyanide in Comets --- Excitation Conditions and Radio Observations of Comet IRAS-Araki-Alcock (1983d)", Bockelée-Morvan, D., Crovisier, J., Baudry, A., Despois, D., Perault, M., Irvine, W.M., Schloerb, F.P., and Swade, D., *Astron. Astrophys.*, **141**, 411 (1984).
92. "Radioastronomical Observations of Comets IRAS-Araki-Alcock (1983d) and Sugano-Saigusa-Fujikawa (1983e)", Irvine, W.M., Abraham, Z., A'Hearn, M., Altenhoff, W., Andersson, Ch., Bally, J., Batrla, W., Baudry, A., Bockelée-Morvan, D., Crovisier, J., DePater, I., Despois, D., Ekelund, L., Gérard, E., Heiles, C., Hollis, J.M., Huchtmeier, W., Levreault, R., Masson, C.R., Palmer, P., Perault, M., Richard, L.J., Sargent, A.I., Scalise, E., Schloerb, F.P., Schmidt, S., Stark, A.A., Stumpff, P., Sutton, E., Swade, D., Sykes, M., Turner, B., Wade, C., Walmlsey, M. Webber, J., Winnberg, A., and Wootten, A., *Icarus*, **60**, 215 (1984).
93. "The Spectra of Orion A and IRC+10216 between 72.2 and 91.1 GHz", Johansson, L.E.B., Andersson, C., Ellder, J., Friberg, P., Hjalmarsen, Å., Höglund, B., Irvine, W.M., Olofsson, H., and Rydbeck, G., *Astron. Astrophys. Suppl.*, **60**, 135 (1985).
94. "The Chemical State of Dense Interstellar Clouds", Irvine, W.M., Schloerb, F.P., Hjalmarsen, Å., and Herbst, E., in *Protostars and Planets II*, ed. D. Black and M. Matthews, Univ. Arizona Press, pp. 579-620 (1985). *Invited Review*.
95. "Recent Observations of Interstellar Molecules in Nearby Cold, Dark Interstellar Clouds", Suzuki, H., Ohishi, M., Morimoto, M., Kaifu, N., Friberg, P., Irvine, W.M., and Matthews, H.E., in *The Search for Extra-Terrestrial Life: Recent Developments*, ed. M. Papagiannis, D. Reidel, Holland, pp. 139-144 (1985).
96. "Search for Molecular Oxygen in Dense Interstellar Clouds", Goldsmith, P. F., Snell, R.L., Schloerb, F.P., and Irvine, W.M., *Ap. J.*, **289**, 613 (1985).
97. "The Detection of Acetaldehyde in Cold Dust Clouds", Matthews, H.E., Friberg, P., and Irvine, W.M., *Ap. J.*, **290**, 609 (1985).
98. "Roughness of the Lunar Soil", Lumme, K., Karttunen, H., and Irvine, W.M., *Earth, Moon, Planets*, **33**, 19 (1985).
99. "Tricarbon Monoxide in TMC-1", Brown, R.D., Godfrey, P.D., Cragg, D.M., Rice, E.H.N., Irvine, W.M., Friberg, P., Suzuki, H., Ohishi, M., Kaifu, N., and Morimoto, M., *Ap. J.*, **297**, 302 (1985).

100. "Astronomical Detection of the C₃H Radical", Thaddeus, P., Hjalmarson, Å., Johansson, L.E.B., Friberg, P., Irvine, W.M., and Linke, R.A., Ap. J. (Lett.), 294, L49 (1985).
101. "The Hydrocarbon Ring C₃H₂ is Ubiquitous in the Galaxy", Matthews, H.E. and Irvine, W.M., Ap. J. (Lett.), 298, L61 (1985).
102. "New Interstellar Masers in Nonmetastable Ammonia", Madden, S., Irvine, W.M., Matthews, H.E., Brown, R.D., and Godfrey, P.D., Ap. J. (Lett.), 300, L79 (1986).
103. "Cometary Observations at Onsala Space Observatory since 1980", Ekelund, L., Andersson, C., Ekelund, A., Irvine, W.M., and Winnberg, A., in Asteroids, Comets, and Meteors II, ed. C.I. Lagerkvist, B.A. Lindblad, H. Lundstedt, and H. Rickman, Univ. Uppsala, pp. 283-288 (1986).
104. "Observations of the Hydrocarbon Ring C₃H₂", Matthews, H.E. and Irvine, W.M., in Masers, Molecules and Mass Outflows in Star Forming Regions, ed. A. Haschick, NEROC, pp. 1-8 (1986).
105. "Molecular Structure of L134N", Swade, D.A., Schloerb, F.P., Irvine, W.M., and Snell, R.L., in Masers, Molecules, and Mass Outflows in Star Forming Regions, ed. A. Haschick, NEROC, pp. 73-88 (1986).
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