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Education

Ph.D. in Atmospheric and Space Sciences. (April 2001) University of Michigan, Ann Arbor. *Hydrocarbons and condensible volatiles of Jupiter's Galileo Probe entry site.* Thesis advisors: Sushil Atreya and Paul Mahaffy.

M.S. in Atmospheric and Space Sciences. (June 1998) University of Michigan, Ann Arbor. Advisor: Sushil Atreya.

A.B. in Astrophysics. (May 1994) University of California, Berkeley. Honors thesis: *Spatial distribution of synchrotron radiation in Jupiter's magnetic field.* Honors thesis advisor: Imke de Pater.

Diploma. (June 1990) James Lick High School, San Jose CA.

Professional experience and service

Associate Specialist. (June 2006–present) At UC Berkeley Astronomy. Funded both by existing and self-initiated grants in support of Hubble Space Telescope and ground-based programs. Conducted studies of Jupiter's atmosphere and small solar system bodies.

Special Session Co-Convener and Chair. (December 2007) "New Horizons—and the upheaval—at Jupiter." At the Fall AGU meeting, San Francisco CA.

Postdoc. (September 2003–May 2006) At UC Berkeley Astronomy. Funded both by existing research grants to Imke de Pater and by self-initiated grants in support of Hubble and Spitzer Space Telescope programs. Conducted studies of Jupiter's atmosphere, small solar system bodies, and Jupiter's rings.

Graduate Fellowship Review Panelist. (2006, 2008). For the NSF Graduate Research Fellowship Program.

Lecturer. (Summer 2004, 2005, 2007) At UC Berkeley. *Astro 10: Introduction to General Astronomy* and *Astro/EPS C12: The Planets.* Developed syllabus, exams, and assignments. Lectures, demonstrations, office hours, field trips.

National Research Council Research Associate. (May 2001–July 2003) At NASA Goddard Space Flight Center (GSFC) with Gordon Bjoraker and the Cassini CIRS team. Analyzed thermal infrared spectra of Jupiter, making the first identification of the 10-μm ammonia ice spectral signature.

Grant Proposal Review Panelist. (Fall 2001). For the NASA Planetary Atmospheres Program.

Graduate Student Research Assistant. (January 1995–February 2001) At University of Michigan and NASA GSFC with Sushil Atreya and Paul Mahaffy.

Graduate Student Instructor. (Fall 1998) At University of Michigan. *Astro 101: Introductory Astronomy: The Solar System.* Delivered lectures, operated the planetarium star projector, created/graded assignments.

Laboratory Assistant, Course Reader. (September 1993–January 1995) At the UC Berkeley Astronomy Department / Radio Astronomy Lab with Imke de Pater, used AIPS to reduce VLA radio maps of Jupiter's synchrotron emission. Graded papers and held office hours for a 16-student upper-division astronomy course on solar system science (Astro 149) and a large, lower-division introductory planetary science course (Astro/Geo 12).

Other miscellaneous work experience. Radio DJ at WCBN-FM, Ann Arbor—did programs including the "Protoplanetary Nebula." Computer Systems Consultant III at University of Michigan—provided computer and AV support. Graphic and web design—created logos, technical illustrations, print documents, and websites.

Teaching interests

Experience. Previous courses taught at the university level have been limited to introductory astronomy and planetary science courses (at UM and UCB; see work experience above) and substitute lectures in Sushil Atreya's upper division atmospheric thermodynamics course (UM). I am also mentoring undergraduate and graduate student researchers at UC Berkeley and at SRI.

University graduate interests. I have served on the NSF Review Panel for physics/astronomy graduate fellowships, but I have not yet acted as an advisor for a graduate student. I look forward to such a role as soon as I secure employment status conducive to long-term academic relationships.

University undergraduate interests. My experience in developing a syllabus and lecture materials for Introductory Astronomy is good preparation for the development of lectures in other natural science areas, including topics such as solar system science, atmospheric and oceanic science, climate studies, astrobiology, thermodynamics, radiative transfer, and computational techniques. Research activity is a crucial part of undergraduate education, and I have been fortunate to work with undergraduate researchers in almost all my projects since moving to UC Berkeley.

K-12 interests. I have given and planned guest lectures for 1st and 3rd grade classes. Given the opportunity, I would love to develop an "Air on Other Worlds" unit to introduce planetary atmospheres to students at any grade level.

Teaching philosophy

Guiding principles.
I find that maintaining a core set of teaching principles helps to focus course planning, assignment preparation, and in-classroom teaching. These principles have been shaped by my experience teaching introductory astronomy; I expect future teaching assignments to help expand and refine these principles.

Balance goals. I found that lower division students and the university often have different goals. The university's goal, in requiring a general science course as part of its core curriculum, is to teach basic science to all its students. But half of the students' goals are simply to look at pretty pictures and to get a good grade in the course, while the other half of the class has a deep and genuine interest in the subject matter. Although the latter goal is more motivating to me, I still place importance on meeting the goals of the less-interested half of the class. I expect upper division and graduate courses to have a different goal, more equally shared between the students and the school: to transmit practical specialized knowledge that will be useful for future employment and/or further education. At the advanced level, I plan to emphasize problem solving skills and emphasize the ability to locate and utilize specialized information over memorization of figures or specific problems.

Stimulate interest. In Astro 10, I approached this goal by tracking the latest discoveries and emphasizing the diversity of truly bizarre astrophysical environments, objects, and events—from oceans under Europa's icy crust and Sun-grazing comets to violently merging neutron stars and dark matter. Another approach to this goal is to focus on aspects of the course that are of particular interest to students, either by allowing them to choose their own project topics or by promoting interaction and then revising lesson plans to follow expressed student interest.

Encourage interaction. Individual students have preferences for particular avenues of interaction. Some students like to chat right after lecture, some will regularly come to office hours, and a select few will actually raise their hands and speak in lecture. Some interact only through email. All of these avenues of interaction should be encouraged. When a student asks for help with a homework question, or clarification of a concept from lecture, I like to use the interaction to make them answer their own question. In summer 2008 I will test using a Facebook.com discussion group as a means of stimulating student interaction.

Celebrate diversity. Minority representation has been slowly increasing in the natural sciences, in classrooms in the USA. My contribution towards celebrating diversity consists of accommodating needs of students based on their diverse backgrounds, and (for Astro 10) emphasizing current and historical minority contributions to astronomy within the course.

Research projects

Research focus.
My primary focus is on clouds and cloud-forming gases in Jupiter's atmosphere. Jupiter's inventory of these species was delivered via accretion of planetesimals, so this study is cosmochemically related to planetary formation. At the UC Berkeley Astronomy Department, I have accumulated ground-based (and 1-AU) telescopic experience, supplementing my previous research techniques of numerical modeling and spacecraft data analysis.

Jupiter's clouds and hazes. (May 2001–present)
Collaboration with Imke de Pater, Philip Marcus, Gordon Bjoraker and members of the CIRS team, Konstantinos S. Kalogerakis, Xylar Asay-Davis, Sean Lockwood, Anand Oza, and Christopher Go.

When amateur astronomer Chris Go noted the color change of Oval BA in February 2006, we were spurred to observe the planet with Hubble Space Telescope's (HST) ACS. UC Berkeley fluid dynamicist Philip Marcus had predicted climate change on Jupiter based on the evolution of this oval. I played a large role in this project from the proposal stage, through observation planning and initial data processing. We performed follow-up observations with Keck and HST in 2006 and 2007. Detailed analysis and publication of results is now underway.

I am involved with laboratory studies by Kostas Kalogerakis, in which NH_3 ice is exposed to hydrocarbon contamination in order to investigate the spectral masking of ammonia ice signatures. This project is a direct investigation into the mystery of Jupiter's widespread NH_3 ice clouds, which strangely show NH_3 ice spectral signatures only in isolated locations. We detected one such NH_3 ice spectral signature, at 10 μm, in spectra obtained with Cassini's Composite InfraRed Spectrometer (CIRS). This is the most spectrally unambiguous detection of ammonia ice to date. Using optical scattering and multistream radiative transfer codes to model the thermal infrared spectrum, we constrained particle size and vertical distribution of the detected ammonia ice aerosol.

Cloud forming gases in Jupiter's atmosphere. (January 2004–present)
Collaboration with Imke de Pater, Sushil Atreya, Franck Marchis, Paul Mahaffy, and Tobias Owen.

We obtained HST NICMOS images of Jupiter in March 2005, revealing the upper-level distribution of NH_3 gas and related clouds. We detected NH_3 enhancements in locations thought to have strong upwelling from below. We obtained supporting ground-based observations at 5 μm with the IRTF and at 2 and 3.6 cm with the VLA, in order to simultaneously determine the spatial distribution of deeper clouds and NH_3 gas at the 2–3 bar level. The variable ammonia concentration will allow us to trace atmospheric motions and thereby improve the understanding of jovian atmospheric dynamics and cloud microphysics.

My thesis work included development of tools for calibration and data reduction of the only set of *in situ* composition measurements of Jupiter ever obtained. Mixing ratios of the cloud-forming condensible volatiles (NH_3 , H_2S, H_2O) and methane were obtained using the 13–18 and 34 amu mass spectrum. I used an equilibrium cloud condensation model and developed an entraining downdraft model to aid in interpretation of the unexpected desiccation of condensible volatiles in the probe entry site.

Titan's drizzle. (September 2006–present)
Collaboration with Máté Ádámkovics.

Using VLT and Keck infrared data-cubes, we discovered wide-spread thin methane condensation clouds and drizzle on Titan. These findings are consistent with Huygens Probe results and characterize an important part of Titan's meterological methane cycle.

Small bodies in the outer Solar System. (November 2003–present)
Collaboration with Franck Marchis and Imke de Pater.

With Franck Marchis I conducted laser-guided adaptive optics observations at Keck of Jupiter Trojan asteroids, resulting in the discovery of the only moonlet Trojan binary, and the first binary Trojan system in the L4 swarm. A small-telescope campaign supported this work with optical lightcurves of Trojans. The basic characterization of these small primordial bodies yields insight into the earliest stages of Solar System formation. With Imke de Pater, I have acquired spectra of the 10-μm silicate dust feature in the coma of comet 2001/Q4 (NEAT) with the Keck LWS.

Planetary ring studies. (September 2003–July 2006)
Collaboration with Imke de Pater, and Mark Showalter.

I obtained Spitzer Space Telescope data in February 2005 to try to obtain the first thermal infrared spectra of Jupiter's ring. With Imke de Pater, I analyzed Keck images and spectra of Jupiter's ring in back-scattered sunlight between 1.6 and 4.1 μm.

Refereed publications

Wong, M.H., J. Lunine, S.K. Atreya, T. Johnson, P.R. Mahaffy, T.C. Owen, T. Encrenaz (2008) Oxygen and other volatiles in the giant planets and their satellites, in *Reviews in Mineralogy and Geochemistry: Oxygen in the Solar System*, Chapter 10 (G. MacPherson, D.W. Mittlefehldt, J. Jones, S.B. Simon, eds.), Mineralogical Society of America, Chantilly, VA.

Sánchez-Lavega, A., G.S. Orton, R. Hueso, E. García-Melendo, S. Pérez-Hoyos, A. Simon-Miller, J.F. Rojas, J.M. Gómez, P. Yanamandra-Fisher, L. Fletcher, J. Joels, J. Kemerer, J. Hora, E. Karkoschka, I. de Pater, M.H. Wong, P.S. Marcus, N. Pinilla-Alonso, and the IOPW team (2008) Depth of the strongest Jovian jet from a planetary-scale disturbance driven by storms. *Nature* 451, 437–440.

Kalogerakis, K.S., J. Marschall, A.U. Oza, P.A. Engel, R.T. Meharchand, M.H. Wong (2008) The coating hypothesis for ammonia ice particles in Jupiter: Laboratory experiments and optical modeling. *Icarus*, doi:10.1016/j.icarus.2008.03.001.

Descamps, P., F. Marchis, J. Pollock, J. Berthier, F. Vachier, M. Birlan, M. Kaasalainen, A.W. Harris, M.H. Wong, W.J. Romanishin, E.M. Cooper, K.A. Kettner, P. Wiggins, A. Kryszczynska, M. Polinska, J.-F. Coliac, A. Devyatkin, I. Verestchagina, D. Gorshanov (2008) New determination of the size and bulk density of the binary asteroid 22 Kalliope from observations of mutual eclipses. *Icarus*, doi:10.1016/j.icarus.2008.03.014.

Ádámkovics, M., Wong, M.H., C. Laver, I. de Pater (2007) Widespread morning drizzle on Titan. *Science* 318, 962–965.

Wong, M.H., I. de Pater, M.R. Showalter, H.G. Roe, and B. Macintosh (2006) Groundbased near infrared spectroscopy of Jupiter's ring and moons. *Icarus* 185, 403–415.

Marchis, F., D. Hestroffer, P. Descamps, J. Berthier, A.H. Bouchez, R.D. Campbell, J.C.Y. Chin, M.A. van Dam, S.K. Hartman, E.M. Johansson, R.E. Lafon, D. Le Mignant, I. de Pater, P.J. Stomski, D.M. Summers, F. Vachier, P.L. Wizinovich, and M.H. Wong (2006) A low density of 0.8 g cm^{-3} for the Trojan binary asteroid 617 Patroclus. *Nature* 439, 565–567.

Atreya, S.K., A.S. Wong, K.H. Baines, M.H. Wong, and T.C. Owen (2005) Jupiter's ammonia clouds—localized or ubiquitous? *Planetary and Space Science* 53, 498–507.

Wong, M.H., G.L. Bjoraker, M.D. Smith, F.M. Flasar, C.A. Nixon (2004) Identification of the 10-μm ammonia ice feature on Jupiter. *Planetary and Space Science* 52, 385–395.

Wong, M.H., P.R. Mahaffy, S.K. Atreya, H.B. Niemann, T.C. Owen (2004) Updated Galileo probe mass spectrometer measurements of carbon, oxygen, nitrogen, and sulfur on Jupiter. *Icarus* 171, 153–170.

Roos-Serote, M., S.K. Atreya, M.H. Wong, P. Drossart (2004) On the water abundance in the atmosphere of Jupiter. *Planetary and Space Science* 52, 397–414.

Atreya, S.K., P.R. Mahaffy, H.B. Niemann, M.H. Wong, T.C. Owen (2003) Composition and origin of the atmosphere of Jupiter—An update, and implications for the extrasolar giant planets. *Planetary and Space Science* 51, 105–112.

Owen, T., P.R. Mahaffy, H.B. Niemann, S.K. Atreya, M.H. Wong (2001) Protosolar nitrogen. *Astrophysical Journal* 553: L77–L79.

Atreya, S.K., M.H. Wong, T.O. Owen, P.R. Mahaffy, H.B. Niemann, I. de Pater, P. Drossart, Th. Encrenaz (1999) A Comparison of the Atmospheres of Jupiter and Saturn: Deep atmospheric composition, cloud structure, vertical mixing, and origin. *Planetary and Space Science* 47, 1243–1262.

Atreya, S.K., M.H. Wong, T.C. Owen, H.B. Niemann, P.R. Mahaffy (1997) Chemistry and clouds of Jupiter's atmosphere: a Galileo perspective, in *The Three Galileos: The Man, the Spacecraft, the Telescope*, pp. 249–260 (C. Barbieri et al., eds.), Kluwer Academic Publishers, Dordrecht, the Netherlands.

Owen, T.C., S.K. Atreya, M.H. Wong, P.R. Mahaffy, H.B. Niemann (1997) On the origin of Jupiter's atmosphere and the volatiles on the Medicean stars, in *The Three Galileos*, pp. 289–297.

Wong, M.H., I. de Pater, C. Heiles, R. Millan, R.J. Maddalena, M. Kesteven, R.M. Price, M. Calabretta (1996) Observations of Jupiter's 20-cm synchrotron emission during the impacts of comet P/Shoemaker-Levy 9. *Icarus* 121, 457–468.

Select non-refereed papers, presentations, and posters

Wong, M.H. (2007) Equatorial clouds and haze before, during, and after Jupiter's global upheaval. Fall AGU Meeting, 10–14 December, San Francisco.

Wong, M.H., I. de Pater, K.H. Baines, S. Lockwood, P. Lii (2007) The drying effect of Jovian thunderstorms. 39th Annual Meeting, Division for Planetary Sciences of the American Astronomical Society, 7–12 Oct., Orlando FL.

Wong, M.H., K.S. Kalogerakis, J. Marschall, A.U. Oza, P.A. Engel, R.T. Meharchand (2007) Masking Jupiter's ammonia-ice spectral signatures—the effects of size, shape, and coatings. Workshop on Planetary Atmospheres, 6–7 November, Greenbelt, MD.

de Pater, I., P. Marcus, M.H. Wong (2007) Jupiter's new "Red Oval." In *Hubble 2006: Science Year in Review*, pp. 32–41 (Robert Brown, ed.), STScI for NASA GSFC, Baltimore MD.

Wong, M.H. (2007) Water in the outer planets. Invited UCB Center for Integrative Planetary Science (CIPS) seminar for *Astro 250: The Role of Water in Planetary Science*. 18 April, Berkeley CA.

Wong, M.H. (2006) Nitrogen in Jupiter: Clouds and cosmochemistry. Invited CIPS seminar. 27 September 2006, Berkeley CA.

Wong, M.H. (2006) Nitrogen in Jupiter: Clouds and cosmochemistry. Invited seminar at SRI International. 17 August 2006, Menlo Park CA.

Wong, M. H., de Pater, I., Sault, R. J., Lockwood, S., and Marchis, F. (2006) Comprehensive Jupiter Ammonia Map. 38th Annual DPS Meeting, Pasadena CA.

Other 2006 DPS abstracts: Velocities and Temperatures of Jupiter's Great Red Spot and the New Red Oval and Their Implications for Global Climate Change (P.S. Marcus *et al.*), Studies on Ammonia Spectral Signatures Relevant to Jupiter's Clouds (K.S. Kalogerakis *et al.*), Search of Binary Jupiter-Trojan Asteroids with Laser Guide Star AO systems: a moon around 624 Hektor (F. Marchis *et al.*).

Wong, M.H., S.K. Atreya, P.R. Mahaffy (2005) Oxygen and other volatiles in Jupiter: Insights into the early Solar System. Invited talk at the Workshop on Oxygen in the Earliest Solar System. 19–22 September 2005, Gatlinburg TN.

Wong, M.H., I. de Pater (2005) Ammonia plumes in the Great Red Spot turbulent wake. 37th Annual DPS Meeting, Cambridge UK.

Wong, M.H., I. de Pater, H.G. Roe, M.R. Showalter (2004) Groundbased near-IR spectroscopy of Jupiter's main ring. 36th Annual DPS Meeting, Louisville KY.

Wong, M.H., G.L. Bjoraker, M.D. Smith, F.M. Flasar, C.A. Nixon (2003) Identification of Jupiter's 10-μm ammonia ice feature in CIRS data. 35th Annual DPS Meeting, Monterey CA.

Wong, M.H., M.D. Smith, G.L. Bjoraker (2002) Modeling the 10-μm ammonia ice feature with non-spherical scattering. At Jupiter after Galileo and Cassini: A conference about the giant planets, Lisbon, Portugal.

Wong, M.H. and P.R. Mahaffy, (2001) Revised deep water mixing ratio in the Galileo Probe Entry Site from GPMS measurements. 33rd Annual DPS Meeting, New Orleans LA.

Roos-Serote, M., S.K. Atreya, M.H. Wong, P. Irwin, and P. Drossart (2001) Jovian tropospheric cloud structure from Galileo/NIMS 5 micron observations. 33rd Annual DPS Meeting, New Orleans LA.

Wong, M.H. (2000) Unsolved mysteries of the entraining downdraft model for Jupiter. At the Informal Jupiter Workshop in Lisboa, Portugal.

Hunten, D.M., A.L. Sprague, and M.H. Wong (2000) Jovian hydrocarbons in the 10 bar region. 32nd Annual DPS Meeting, Pasadena CA.

Wong, M.H., S.K. Atreya, and P.R. Mahaffy (1999) Error analysis of Galileo Probe Mass Spectrometer atmospheric mixing ratio measurements. 31st Annual DPS Meeting, Padova, Italy.

Wong, M.H., S.K. Atreya, and P.N. Romani (1998) Entrainment in the Galileo Probe Site downdraft. 30th Annual DPS Meeting, Madison WI.

Awards / grants

Spitzer Space Telescope. (Cycle 1, 2004–2005) A look at the large end of the jovian ring particle size distribution.

Hubble Space Telescope. (Cycle 13, 2004–2005) Fresh ammonia-ice on Jupiter: The northern equatorial region.

National Research Council Research Associateship. (2001–2003) Simultaneous investigation of NH_3 cloud and gas distributions during the Cassini-Jupiter encounter.

NASA Graduate Students Researchers Program Fellowship. (1996–2000) Investigation of the origin and current state of Jupiter's atmosphere using Galileo Probe Mass Spectrometer measurements.

National Science Foundation honorable mention. (1996)

National Merit Scholarship. (1990–1994)

Chancellor's Scholarship. (1990–1994)

References

Contact info by request: **Prof. Imke de Pater** (UC Berkeley), **Prof. Sushil K. Atreya** (University of Michigan), **Dr. Gordon L. Bjoraker** (NASA/GSFC), **Dr. Kostas Kalogerakis** (Molecular Physics Laboratory, SRI International), **Dr. Paul R. Mahaffy** (NASA/GSFC), **Prof. Phillip Marcus** (UCB), **Dr. Franck Marchis** (UCB/SETI), **Dr. Maarten Roos-Serote** (Lisbon Observatory)**, Dr. Scott G. Edgington** (JPL)**, Dr. Michael D. Smith** (NASA GSFC)**.**