

Daily Planet

FALL 2004

*The Department of
Atmospheric,
Oceanic and Space
Sciences Newsletter*

Thomas M. Donahue 1921 — 2004

AOSS lost one of its most illustrious faculty members on October 16, 2004, when Thomas M. Donahue died from complications following heart surgery. Tom, a leading space and planetary scientist and a pioneer of space exploration, shaped space exploration through his scientific achievements and policy positions. His work began with the first use of sounding rockets following World War II and continues today with the space probes currently exploring the solar system.

Born in Healdton, Oklahoma on May 23, 1921, Tom grew up in Kansas City, graduating in 1942 from the city's Rockhurst College with degrees in classics and physics. Though his graduate work in physics at Johns Hopkins University was interrupted by service in the Army Signal Corps, he obtained his Ph.D. degree in atomic physics from Hopkins in the fall of 1947.

After three years as a post-doctoral research associate and assistant professor at Hopkins, Tom joined the University of Pittsburgh Physics Department in 1951. At Pittsburgh he organized an atomic physics and atmospheric science program that led to experimental and theoretical studies of the upper atmosphere of the Earth and other solar system planets with instruments flown on sounding rockets and spacecraft. He became Professor of Physics in 1959 and eventually Director of the Laboratory for Atmospheric and Space Sciences and



the Space Research Coordination Center at the University. In 1960 he spent a sabbatical year on a Guggenheim Fellowship at the Service d'Aeronomie in Paris, which began a collaboration with French colleagues that flourished for more than 40 years.

In 1974 Tom joined the U-M as the Chairman of Atmospheric and Oceanic Science Department, a position he held until 1981. In 1986, he was named the Henry Russel Lecturer at the University of Michigan, the highest honor the University confers on a faculty member, and in 1987 was named the Edward H. White II Distinguished University Professor of Planetary Science. He also received the Atwood Award from the College of Engineering for excellence in research in 1994.

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AOSS Accolades



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Faculty

Jerry Keeler, AOSS professor, was selected by Michigan Governor Jennifer Granholm to be a member of the Michigan Environmental Sciences Board providing advice to the Governor's office on matters dealing with Michigan's environment.

Mary Anne Carroll, AOSS professor, is a member of the National Academy of Sciences Board on Atmospheric Sciences and Climate as well as a member of the Scientific Steering Committee of the International Geosphere-Biosphere Programme's Integrated Land-Atmosphere-Ecosystem Process Study (iLEAPS) project.

Tamas Gombosi, AOSS chair and professor, is serving on Steering Committee for the NASA Living with a Star (LWS) Targeted Research & Technology (TR&T) 2006 program and is co-chair of the NASA Modeling & Simulation Technology Capability Roadmap Team.

Joyce Penner, AOSS professor, is vice-chair of the National Research Council panel activity for the NASA Climate Variability and Change Roadmap Team.

Christopher Ruf, AOSS professor, is a member of the NASA Science Instruments and Sensors Capability Roadmap Team.

Students

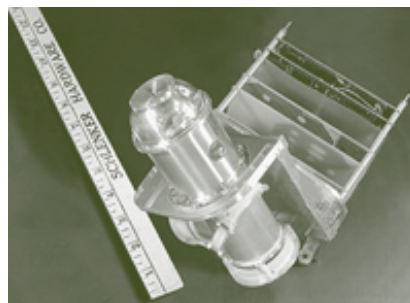
Xiaohua Fang received an Outstanding Student Presentation award at the 2004 NSF-sponsored *Coupling of Energetics and Dynamics of Atmospheric Regions (CEDAR)* workshop. Only five students received this award.

Kelley Korreck published a paper in *Astrophysical Journal* on shock heating of supernova SN1006 titled *Far Ultraviolet Spectroscopic Explorer Observation of the Nonradiative Collisionless Shock in the Remnant of SN1006*. The paper can be accessed online through the ApJ web site or through NASA ADS at http://adsabs.harvard.edu/cgi-bin/nph-bib_query?bibcode=2004ApJ...615..280K&db_key=AST&high=41753a3efc10539.

A statistical study of the geoeffectiveness of magnetic clouds during high solar activity years by **Jichun Zhang**, Michael W. Liemohn, Janet U. Kozyra, Benjamin J. Lynch, and Thomas H. Zurbuchen, was accepted and published in *Journal of Geophysical Research (JGR)-Space Physics*, September 2004. He also gave a student tutorial, *Introduction to geomagnetic storms* at the Geospace Environment Modeling (GEM) 2004 Summer Workshop and was selected as the new student representative of GEM (2004 – 2005).

Pran Mukherjee won both the NASA and the technology specific Goddard Space Flight Center GSRP and accepted the GSFC award as he could not accept both awards in the same year.

AOSS/SPRL BUILT INSTRUMENT HEADS TO MERCURY



MESSENGER, set to become the first spacecraft to orbit the planet Mercury, launched at 2:15:56 a.m., August 3, 2004. MESSENGER (MErcury Surface, Space ENvironment, GEochemistry, and Ranging) should reach the planet closest to the Sun in July 2011 carrying the Fast Imaging Plasma Spectrometer (FIPS) instrument built by AOSS/SPRL. More information about AOSS participation in space missions is on the web at: <http://aoss.engin.umich.edu/research/space.missions>.



Graphic design by Brian Grimm

AOSS Hosts NASA Workshop on Radiation Shielding

On August 16-17, 2004, AOSS hosted the NASA Marshall Space Flight Center (MSFC) sponsored workshop, *Active Radiation Shielding for Human Space Exploration*. During the two-day event nearly 50 scientists from around the world presented, discussed and debated methods to shield and protect astronauts from particle radiation during flights beyond the protective shield of the Earth's magnetosphere.

"Conventional shielding, such as thick walls, is far too heavy for space flight," said AOSS Chair and workshop organizer, Tamas Gombosi. "MSFC, as NASA's lead center in this endeavor, is investigating emerging radiation shielding concepts. These ideas are so new and unusual that just evaluating the basic underlying science takes a significant effort."

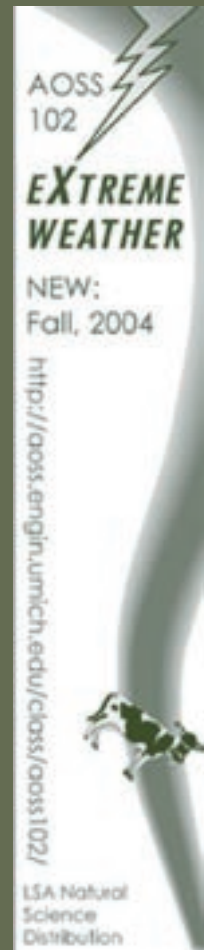
The workshop was organized into a day of major concept presentations, followed by a day of presentations that supported or challenged the concepts, or offered new concepts, and open discussion. The major shielding concepts presented were:

- *Magnetic Faraday Cage with Superconducting Magnets*
Samuel C.C. Ting, MIT *Thomas Dudley Cabot Professor of Physics* and 1976 co-recipient of the Nobel Prize in Physics
- *Blowing Magnetized Plasmas (M2P2)*
Robert Winglee, University of Washington, Professor, Earth and Space Sciences
- *Asymmetric Electrostatic Radiation Shielding*
Robert Youngquist, Kennedy Space Center, Director, Applied Physics Laboratory

On the second day, Eugene N. Parker, University of Chicago *S. Chandrasekhar Distinguished Service Professor Emeritus of Physics, Astronomy, Astrophysics and the Enrico Fermi Institute* and 2003 recipient of the Inamori Foundation Kyoto Prize in Basic Sciences, summed up the concepts and proceedings.

The presentations, summary and list of attendees are available on the web at:

<http://aoss.engin.umich.edu/Radiation>.



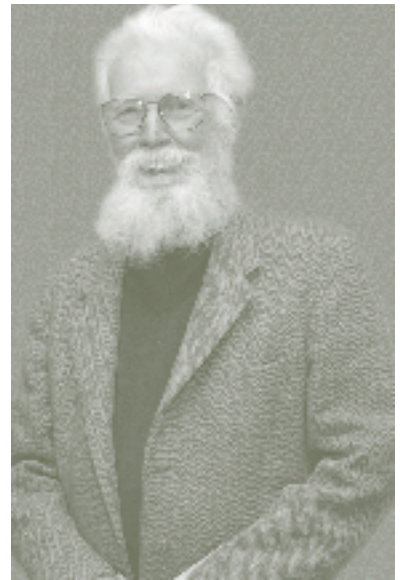
AND THE WEATHER COOPERATED !

AOSS Professor and Associate Chair Perry Samson taught a new AOSS class this fall, *Extreme Weather*, and Mother Nature helped by sending numerous hurricanes to Florida. What more could a class ask for!

Thomas M. Donahue Memorial Student Fund

“I want to know how the planets of the solar system were formed, how they came to evolve as they did and the significance of all that for the existence of life in the solar system and in the rest of the universe.”

— Thomas Donahue



While Tom may now be silent, his unquenchable desire to learn and then to learn more will remain part of his legacy for generations to come. It is in this spirit that the Department of Atmospheric, Oceanic and Space Sciences, working closely with Tom’s family, is establishing the Thomas M. Donahue Student Memorial Fund. The Donahue family has requested that in lieu of other tributes to Tom, a contribution be made to the fund to assist AOSS students in their quest to learn more about the universe in which we live.

Tom was very much an educator as well as a scientist and to support students in their academic endeavors was very much part of him and the basis for establishing the fund. We would encourage you to take a moment and help us remember Tom through the student fund; we would love to list you among the donors. You can send your donations to:

Thomas M. Donahue Student Memorial fund
Department of Atmospheric, Oceanic and Space Sciences
Room 2209 SRB
2455 Hayward Street
Ann Arbor, MI 48109-2143

Alumni News

Brian Hornbuckle, Ph.D., AOSS/EECS Geoscience & Remote Sensing Program, 2003, won the British Hydrological Society 2004 Prize for *Best Paper and Presentation by a Young Hydrologist*. The research was done at U-M. In 2003, Brian began a joint assistant professor appointment at Iowa State University in Agronomy and Electrical & Computer Engineering.

Deceased Classmates

Renee K. Fox, BS, 1981.

If you're an AOSS alumni/ae and have information you'd like to share with others in the AOSS community, please send the information to aossnews@umich.edu and we'll include it in an upcoming issue of the *Daily Planet*. You can also update your contact information with the University from the AOSS web site. Visit <http://aoss.engin.umich.edu> and click on ALUMNI at the top of the page.

Donahue

CONTINUED FROM PAGE 1

Elected to the National Academy of Sciences in 1983 and to the International Academy of Astronautics in 1986, Tom was a Fellow of the American Geophysical Union and the AAAS, and received an honorary degree of Sc.D. from Rockhurst College in 1981. The same year he was awarded the Arctowski Medal by the National Academy of Sciences and the John Adam Fleming Medal by the American Geophysical Union. He received the NASA Distinguished Public Service Medal, two NASA Public Service Awards, the Space Science Award of the American Institute of Aeronautics and Astronautics, and the National Space Club Science Award.

From 1982 to 1988 he was Chairman of the Space Science Board of the National Research Council of the National Academy of Science, where he was a strong advocate for unmanned space science missions within the federal space budget. He also served on numerous governmental, NRC, and National Academy of Science advisory boards and committees, and was an officer on the boards of several university consortia, such as the University Corporation for Atmospheric Research and the Universities Space Research Association. He recently served terms as chairman of the Visiting Committee for the Space Telescope Science Institute, the Arecibo Advisory Board and Visiting Committee, the Max Planck Institute for Aeronomy, and the Committee to Visit the Department of Earth and Planetary Sciences at Harvard University. He was Chairman of the Committee on Public Policy of the American Geophysical Union and authored more than 200 research publications.

Tom's influence in space exploration spanned many decades and diverse projects. Along the way, Tom found time to participate in space and planetary science and space exploration where his influence was immeasurable, beginning with his early experiments with sounding rockets and spacecraft in the early 1950s and continuing through to the current Cassini Mission to Saturn.

He was an experimenter or interdisciplinary scientist on the orbiting Geophysical Observatory Missions, Apollo-17, Apollo-Soyuz, Voyager, Pioneer Venus Multiprobe and Orbiter, Galileo, Comet Rendezvous Asteroid Flyby, and Cassini. Based on observations by the Pioneer Venus entry probe, he concluded that Venus once had an ocean before a runaway greenhouse effect led it to its current state. Analyzing similar data from Martian meteorites, he again argued for

a substantial Martian ocean, anticipating the current series of missions to Mars. In these and many other cases he laid the foundation for our current understanding of planetary atmospheres.

In 1999, Tom described his career this way, "I parlayed my training in atomic physics into a faculty position at Pitt, doing research in aeronomy and laboratory studies of atomic physics. This led to rocket and satellite exploration of the upper atmosphere of Earth in the 60s and spacecraft exploration of Mars, Venus and the Outer Planets beginning in the 70s. Along the way my students, post-docs and I were deeply involved in the problem of anthropogenic destruction of the stratospheric ozone in the early 70s. This led to my continuing interest in global change."

Throughout his life Tom retained a keen interest in the history of his family in Ireland, as his mother and grandfather both emigrated from County Kerry. He studied oral and written sources, writing as early as 1942 on the family and the early history of the Eóghanachta Rathleinn. Recently his efforts supported the establishment of the international O'Donoghue society, in particular spearheading a project that continues to reveal fresh detail about family migrations from the High Kings to the Cromwellian period.

Tom brought his powerful intellect and drive to a broad range of lifelong passions beyond science. Fluent in several languages, from classical Greek to modern Irish, he was also widely read in American, Irish and French history and literature, and was an exacting student of French wine. He loved classical and folk music, often singing hundreds of songs for his family in keys only he knew. A devotee of tennis, he continued playing weekly matches until early 2004, and was able to attend one last ceremony honoring him when U-M and his home department, AOSS, awarded his friend and fellow SSB chair, Lennard Fisk, the "Thomas M. Donahue Collegiate Professor of Space Science".

He is survived by his wife of 54 years, Esther McPherson Donahue of Ann Arbor, Michigan; their three sons -- Brian of Boston MA, Kevin of Berkeley CA and Neil of Pittsburgh PA; six grandchildren; a brother, Robert Donahue, and sister, Mary Marshall, both of Missouri.

New Grants

(Only AOSS Principal Investigators are listed)

C. Robert Clauer, GSRP: DeJong: Polar UVI Auroral Images to Classify and Study Magnetospheric Events; NASA; through August 2007; \$72,000.

Michael Combi, Volatile Abundances in Comet C/2001 Q4 (NEAT): FUSE Cycle 5, NASA/Goddard Space Flight Center; through April 14, 2005; \$5,000. *Observations of Comet Bombardment, Planetary Aurorae, and Chromospheric Activity in the Young Stars E-Eri and X-Ori: FUSE Cycle 5*; through August 2005; \$18,473. *Advanced Techniques for High-Performance Computer Simulations of Rarefied Neutral Gas and Plasma Flow*; through September 2005; \$77,557.

Paul Drake, *Diagnostic Testing and NIKE Experiments*; Department of the Navy, Defense Department; through June 7, 2005; \$17,267. *Experimental Astrophysics on the Omega Laser*; Department of Energy; two years; \$360,890.

Charles Edmonson, *IR&D Layered Patch Antenna Fabrication*; Research Triangle Institute; through October 3, 2004; \$7,165.

Lennard A. Fisk, *Acceleration of Suprathermal Particles in the Solar Wind*; NASA; through April 2005; \$25,000.

Tamas Gombosi, The Center for Multiscale Plasma Dynamics; Department of Energy; through July 2009, \$475,000. *Block-Adaptive Parallel Implicit Methods for Semirelativistic Multifluid Hall-MHD*; NASA, AISRP; through September 2007; \$576,812. *Interdisciplinary Scientist (IDS) for the Cassini Interdisciplinary Magnetosphere and Plasma Investigation: MO&DA Efforts*; NASA/JPL; through September 2008; \$1,218,000.

Patrick Koehn*, *The Innovative Interstellar Explorer*; APL; through March 2005; \$25,000.

Tariq Majeed, *CFHT Observations of Ion and Neutral Winds in Jupiter's Auroral Thermosphere*; SWRI; through July 2007; \$21,134.

Frank Marsik, *Air-Surface Exchange of Mercury Over Sewage sludge Amended Soils*; University of Toledo; through June 14, 2005; \$75,293.

Andy Nagy, *Global Geospace Science (GGS)/POLAR Thermal Ion Dynamics Experiments (TIDE)*; Co-Investigator Program: MODA; NASA; through May 14, 2007; \$102,876.

Joyce Penner, *Absorbing Aerosol Effects on Climate: Comparison of Modeled and Measured Surface and Midtroposphere Temperature Trends*; Department of National Oceanic and Atmosphere; through April 2005; \$12,859. *A Proposed Model Intercomparison Study to Quantify Uncertainties Associated With Indirect Aerosol Radiative Forcing*; NASA; through September 2005; \$185,685.

Nilton Renno, *Campaign Methodologies for Exploration-Driven System-of-Systems Architectures*; NASA; January 2005 – December 2006; \$449,286. *MSL instrument: Rover Environmental Monitoring Station (REMS)*; Spanish Ministry of Science & Technology and NASA. Gift support for AOSS-ENG 450; General Motors; \$150,000.

Aaron Ridley, *Advancement and Validation of Real-TIME AMIE for Space Weather Applications*; National Science Foundation; through July 2007; \$300,000.

Ilia Roussev* & Igor Sokolov*, *Numerical Modeling of SHINE Campaign Events by Means of Coupled MHD-SEP Simulations*; National Science Foundation; January 2005 – January 2008; \$291,500.

Christopher Ruf, *Development of the Aquarius Science Algorithm and Calibration/Validation Plan*; NASA; through July 1, 2012; \$630,000. *Calibration and Validation of Microwave Radiometer Wet Path Delay Retrievals for TOPEX/Poseidon, Jason and OSTM*; JPL; through November 1, 2011; \$276,018.

J. Hunter Waite, *Organic Analysis Using Pyrolysis/Extraction and Comprehensive Two Dimensional Gas Chromatography*; NASA/Goddard Space Flight Center; through June 2007; \$600,000.

Thomas Zurbuchen, *Composition Instrument for a Solar Polar Orbiter*; JPL; through May 2005; \$14,000. *Development of Novel MEMS-Based Technologies for Solar Physics Experiments Mukherjee GSRP*; NASA/Goddard; through May 2005; \$24,000. *Solar Wind Conference Series and SOHO Workshops*; NASA; through December 2005; \$23,480. *Time-of-Flight Instruments*; NASA; through August 2007; \$256,886. *Inner Heliosphere Multispacecraft Data Analysis Tool*; UCB; through February 2006; \$56,424. *Constraining Solar Wind and CME Models using In Situ Composition Observations*; NSF; through December 2007; \$299,847.

* First grant as Principal Investigator.

Martin Mlynczak Receives '04 Alumni Society Merit Award

Martin G. Mlynczak was this year's AOSS alumnus recipient of the CoE Alumni Society Merit Award. Dr. Mlynczak, who received his Ph.D. in 1989, is currently Senior Research Scientist of Atmospheric Sciences at NASA Langley Research Center.

Dr. Mlynczak received his award at a gala dinner during the Michigan Engineering Alumni Weekend, October 7 – 9. In addition to College events, Dr. Mlynczak gave a seminar in the Department titled, *Exploring the First Law from the Earth's Surface to the Edge of Space*. He also



Professor Emeritus Roland Drayson, 2004 Alumni Society Merit Award Recipient Martin Mlynczak, Pam Mlynczak and AOSS Professor John Barker.

spent time visiting AOSS friends including his graduate committee chair, Professor Emeritus Roland Drayson, and Professor John Barker who nominated him for this

year's award.

The research areas of interest to Dr. Mlynczak include calculation, modeling and observation of atmospheric

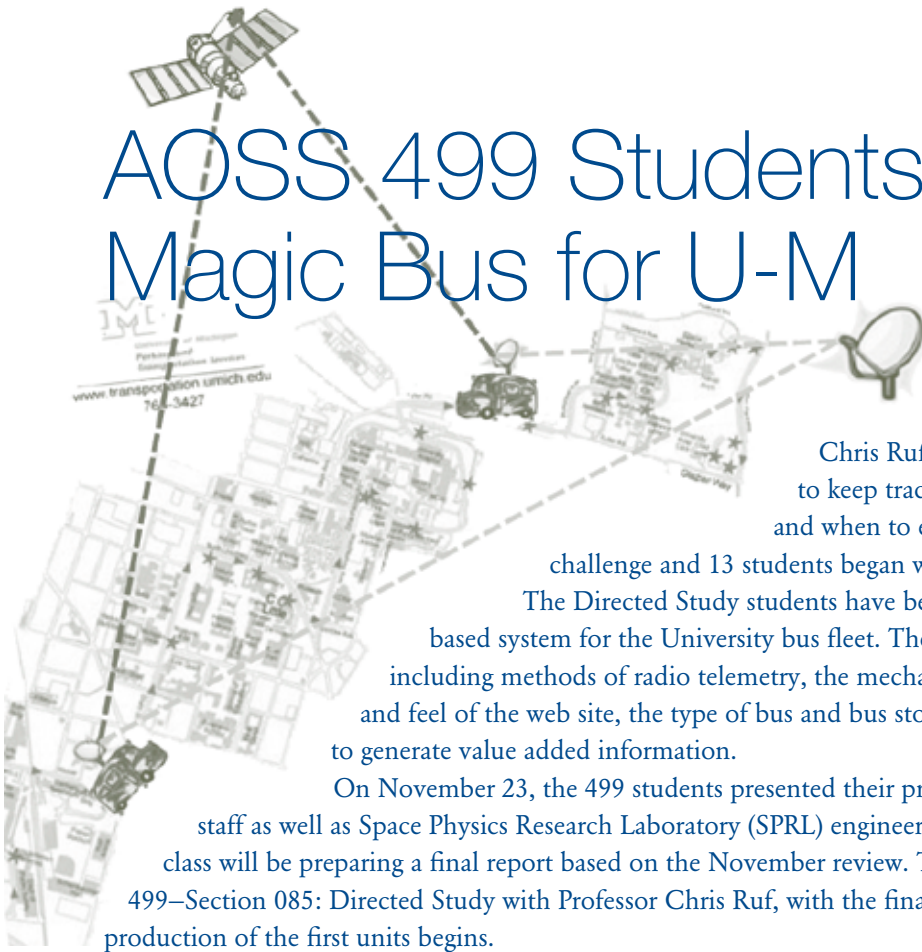
thermodynamics, energy budgets and structure from satellite, aircraft, balloon and ground-based instruments. In addition to his role as senior research scientist at NASA, he is a member of the NASA Earth Sciences Vision 2030 Steering Group, the Associate Editor of the *Journal of Geophysical Research – Space Physics*, Affiliate Scientist at the High Altitude Observatory, National Center for Atmospheric Research, and a member of the Observatory's Director's Advisory Committee.

"Michigan provided me with a firm foundation on which to build a solid scientific career. I was allowed to find my own way and to do research which today is being used to analyze data from the TIMED mission."

— Marty Mlynczak, '89



AOSS 499 Students Design a Magic Bus for U-M



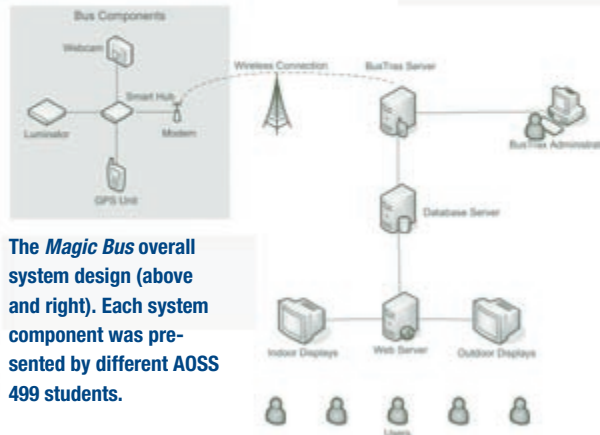
During the past summer, University of Michigan Transportation Services came to AOSS Professor Chris Ruf with a possible student design project – “We need to keep track of our buses, tell our patrons where the buses are and when to expect them at the bus stops.” Chris accepted the challenge and 13 students began work on the “*Magic Bus*” in September.

The Directed Study students have been designing, fabricating and field-testing a GPS-based system for the University bus fleet. The students explored a broad range of design options, including methods of radio telemetry, the mechanical and electrical interfaces to the bus, the look and feel of the web site, the type of bus and bus stop display screens, and the type of algorithms needed to generate value added information.

On November 23, the 499 students presented their preliminary designs to U-M Transportation Services staff as well as Space Physics Research Laboratory (SPRL) engineers and faced rigorous and productive questioning. The class will be preparing a final report based on the November review. The project will continue winter term, again as AOSS 499–Section 085: Directed Study with Professor Chris Ruf, with the final design presented early in the term, just before production of the first units begins.



Susan Monroe (from the far left) representing the Provost's Office, Keith Johnson, Jordan Gray, Jason Bidwell and Dave Miller (in back) from U-M Transportation Services listen intently to the student presentations.

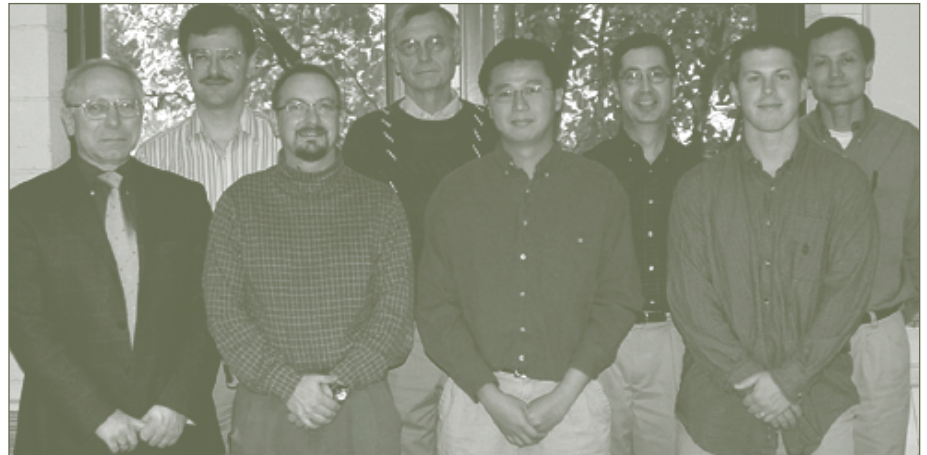


The *Magic Bus* overall system design (above and right). Each system component was presented by different AOSS 499 students.

AOSS Team Receives NASA Group Achievement Award

A team of AOSS and SPRL students, faculty and engineers were recently awarded the NASA *Group Achievement Award* for their work in designing, fabricating and testing the Lightweight Rainfall Radiometer (LRR). According to NASA this award is given to a team for “outstanding accomplishment through the coordination of many individual efforts which has contributed substantially to the NASA mission.”

The team of AOSS Professor and LRR Principal Investigator, Chris Ruf, Shannon Brown, Steve Gross, Pete Hansen, Boon Lim, Steve Musko, and Steve Rogacki began work on the LRR in SPRL. The instrument was then shipped to Goddard Space Flight Center in Maryland for final sensor integration, trucked to the Dryden Research Center at Edwards Air Force Base in California for flight integration on the NASA DC-8, and then tested off the Northern California coast and British Columbia.



Pictured from the left, back row: Steve Rogacki, Pete Hansen, Steve Musko and AOSS Professor/LRR PI Chris Ruf. Front row: AOSS Chair, Tamas Gombosi, Steve Gross, Boon Lim and Shannon Brown.



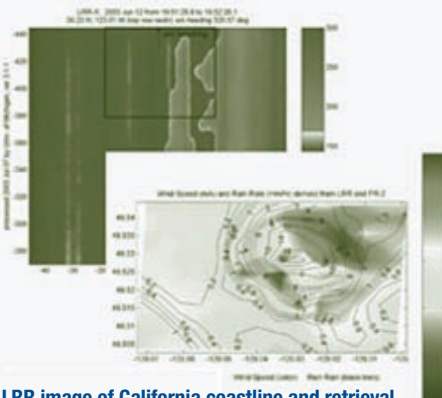
The Lightweight Rainfall Radiometer



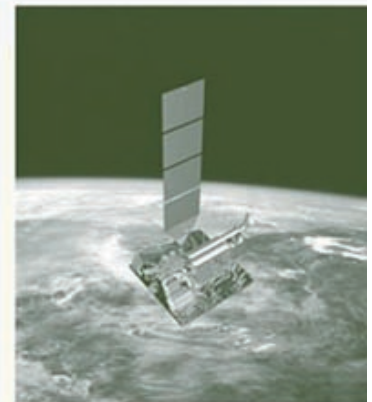
A smile of relief...the software works



Working hard in Northern California



LRR image of California coastline and retrieval of rain rate and underlying wind speed in an extratropical cyclone



Possible future home of the LRR

AOSS Professor Atreya Member of Mars Methane Detection Team

By Laura Bailey, University of Michigan, College of Engineering

AOSS Professor Sushil Atreya is part of a European Space Agency team that has detected methane gas on Mars, and the findings were published in the December 03, 2004 issue of *Science*.

Sushil Atreya, professor and director of the Planetary Science Laboratory in the College of Engineering says the detection of methane is the clearest indicator of the possibility of life on the Red Planet yet.

“Biologically produced methane is one of many possibilities,” Atreya said. “Methane is a potential biomarker, if a planet has methane we begin to think of the possibility of life on the planet. On Earth, methane is almost entirely derived from biological sources.”

Mars resembles Earth more than any other planet in our solar system, and studying its atmosphere gives us a greater understanding of our own.

How the methane got to Mars is the big question, and there are several possible sources, Atreya said. The most exciting scenario is that methanogens—microbes that consume the Martian hydrogen or carbon monoxide for energy and exhale methane—dwell in colonies out of sight beneath the surface of the red planet.

“These are anaerobic so they don’t need oxygen to survive, if they are there,” Atreya said. “If they are there, they would be underground.”

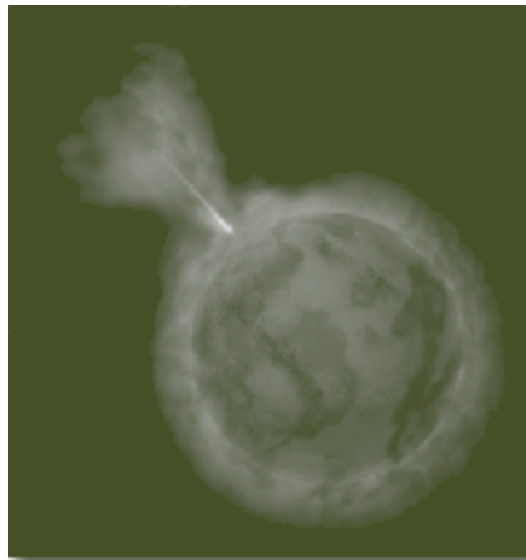


Illustration by NASA/JPL/ESA

Speculation is tempting, but many more experiments are necessary before drawing any conclusions.

“While it’s tantalizing to think there are living things on Mars, we aren’t in a position to say that is what is causing the methane,” Atreya said.

A comet could have struck the planet, which would leave methane behind, but that only happens once every 60 million years or so, Atreya said. A more likely scenario is hydrothermal process involving chemical interaction between rock and water in aquifers below the Martian permafrost.

The instrument that sniffed out the methane is called a planetary Fourier spectrometer, and it is one of seven instruments on board the Mars Express spacecraft. The spectrometer measures the Sun’s infrared light that has been

absorbed, emitted and scattered by the molecules in the Martian atmosphere. Every molecule has a unique spectral property—think of it as an infrared fingerprint—including methane.

The spectrometer detected an average 10 parts per billion by volume (ppbv) of methane on Mars, a small amount compared to the approximately 1700 ppbv on Earth. The methane gas was distributed unevenly over Mars’ surface, which tends to support the theory that an internal, on-site source, rather than a comet, is the source generating the methane, said Atreya.

Mars Express launched in June 2003, and it is the first Western European trip to another planet. More information on Mars Express is available on the web at:

<http://sci.esa.int/science-e/www/area/index.cfm?fareaid=9>.

Editor’s Note: Professor Atreya and his work on the Mars methane discovery have been cited in more than 400 articles around the world since the discovery was first published in *Science Online* on October 28, 2004.

AOSS Professor Waite Studies Titan's Atmosphere

By Katie Gazella, Editor, *University Record*

As the Cassini-Huygens spacecraft conducts more than 40 fly-bys of Saturn's largest moon, one of the main scientists involved in studying its messages is Hunter Waite, professor in the Department of Atmospheric, Oceanic and Space Sciences.

Waite is the team leader of NASA's Cassini Ion and Neutral Mass Spectrometer (INMS) Investigation. The instrument measures positive ions and neutral particles in the atmosphere, and an early fly-by of Titan has turned up some interesting findings.

"We saw a lot of complex carbon molecules, and the fact that they were mixed way into the upper atmosphere was surprising," Waite says. "The major constituent of Titan's atmosphere is nitrogen, just like in Earth's atmosphere. It's a very thick atmosphere, which is surprising for a moon."

There is a small amount of methane as well. Both methane and nitrogen are dissociated by solar ultraviolet photons and energetic particles from Saturn's magnetosphere.

This initiates the complex carbon-nitrile chemistry that forms the haze in the lower atmosphere. The upper atmosphere, he says, appears to be as well-mixed with the lower atmosphere returning this organic mixture to the upper atmosphere where INMS was able to observe it.

Another surprise from the late-October fly-by relates to the isotopic composition of carbon and nitrogen in the upper atmosphere.

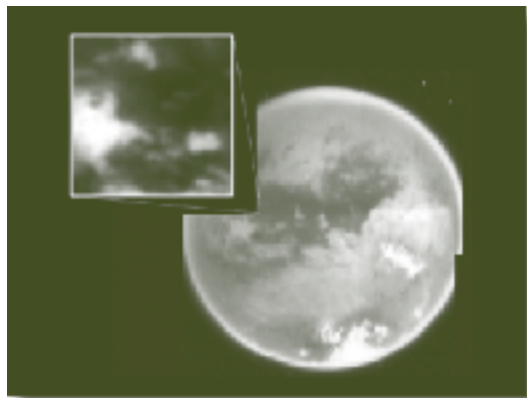


IMAGE COURTESY NASA

Measurements of the enrichment of the heavy isotopic component of nitrogen indicate that Titan has lost more than three-quarters of its atmosphere over time, Waite says.

However, the lack of enriched heavy isotopes in carbon as opposed to nitrogen suggest that methane is out-gassed continuously from the interior of Titan during the evolution of the atmosphere.

He and other scientists also are exploring whether nitrogen comes into Titan's atmosphere as nitrogen, or if it comes in as ammonia and then becomes nitrogen.

"Titan is like the early Earth," he says. "If we learn where the N₂ (molecular nitrogen) on Titan comes from, we might gain a better understanding of where our N₂ came from."

In December, the European-built Huygens probe is scheduled to be released from Cassini. It will make a closer inspection of the moon's surface.

The \$3.3 billion mission—a joint project of NASA and European and Italian space agencies—is a four-year study of Saturn. Titan is a key part of that research because it is the only known moon in the solar system with an extensive, thick atmosphere.

During the fly-by that provided Waite and his team with information about the atmosphere, other scientists said they were mystified by areas of bright and dark material on the moon.

While these cameras provide much sharper images than those previously available, it still is difficult to make them out because of the moon's thick and hazy atmosphere.

Waite hopes many of those mysteries will be solved during later inspections of Titan. More than 40 additional fly-bys are planned.

"There are a lot of very interesting questions that Cassini-Huygens will be able to address," he says. "We expect to learn a lot more about Titan, and to get some more clues about the early Earth."

Editor's Note: Professor Waite was one of four scientists fielding media questions at the latest NASA videoconference, streamed over the Internet and carried on many broadcast and cable networks, on October 27 from the Jet Propulsion Laboratory.

CALENDAR OF EVENTS*

Undergraduate Winter Term Classes Begin

Date: Wednesday, January 5

Graduate Winter Term Classes Begin

Date: Monday, January 10

Atmospheric & Space Seminar: Rosina Bierbaum, Dean, SNRE

Date: Friday, January 14

Location: Room 2246, SRB

Martin Luther King, Jr. Day - no classes

Date: Monday, January 17

Atmospheric & Space Seminar: Tom Delworth, Research Scientist, Geophysical Fluid Dynamics Laboratory, NOAA

Date: Friday, January 21

Location: Room 2246, SRB

Atmospheric & Space Seminar: J. Hunter Waite, Professor, AOSS

Date: Friday, January 28

Location: Room 2246, SRB

Atmospheric & Space Seminar: Michael Mendillo, Professor, Department of Astronomy & Center for Space Physics, Boston University

Date: Friday, February 4

Location: Room 2246, SRB

Atmospheric & Space Seminar: Joyce Penner, Professor, AOSS

Date: Friday, February 11

Location: Room 2246, SRB

Spring Break

Date: Monday-Friday, February 28-March 4

Atmospheric & Space Seminar: Paul Wine, Professor, Schools of Chemistry & Biochemistry and Earth & Atmospheric Science, Georgia Institute of Technology

Date: Friday, March 11

Location: Room 2246, SRB

Annual Nelson W. Spencer Lecture: Vernon Ehlers, Congressman, Michigan Third District, Majority Member, House Committee on Science

Date: Friday, March 18 OR Friday, March 25

Location: TBD

Winter Term Commencement

Date: Friday, April 29

* All events are subject to change without notice. For the latest information, visit the AOSS web site at <http://aoss.engin.umich.edu>.

IN THE NEXT DAILY PLANET

- What's happening in AOSS hands-on courses
- A very beneficial partnership: AOSS and the Jet Propulsion Laboratory
- A look at the women scientists who visited AOSS via the ADVANCE grant
- An update on the AOSS "Virtual Classroom"
- The latest on Sun-to-Earth weather modeling


DID YOU KNOW ...

The AOSS web site now includes up-to-date weather information for Earth and space. Visit <http://aoss.engin.umich.edu> for Ann Arbor and space weather. You'll also find links for:

- Weather Alerts
- Hurricane Alerts
- Climate Alerts
- Solar Storm Alerts

And there's more! At the AOSS Weather page, <http://aoss.engin.umich.edu/go/?id1=12&id2=1&id3=0>, you'll find links to weather conditions around the world. The next time you plan a trip (even if it's to the moon), visit AOSS first for the most up-to-date weather in the universe.

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