Laboratory for Atmospheric and Space Physics

Activity Report
2003
University of Colorado at Boulder
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**Introduction**

This report describes some of the activities of the members of the Laboratory for Atmospheric and Space Physics (LASP) from January 2003 through December 2003. LASP is an institute of the Graduate School of the University of Colorado. LASP conducts basic theoretical and experimental research, exploring fundamental questions in the areas of planetary science, magnetospheric physics, atmospheric composition and processes, and solar physics. A coordinated, multi-objective research program has evolved that uses remote sensing spectroscopic and in situ techniques. The programs are devoted to understanding terrestrial and planetary magnetospheres and atmospheres, and to investigating processes occurring on the Sun. LASP also conducts research to explore the potential uses and development of space operations and information systems, as well as to develop scientific instrumentation. Through LASP’s research programs, University faculty, staff members, and students are able to participate in national space programs. In particular, students from the Department of Astrophysical and Planetary Sciences, the Department of Atmospheric and Oceanic Sciences, the Department of Physics, the Department of Geological Sciences, and the College of Engineering can pursue their research interests under the auspices of the Laboratory.

LASP has taken part in major space exploration missions. This work has demonstrated LASP’s ability to conceive, design, fabricate, test, and operate space vehicles and instruments and to exploit the data from space experiments. This technological and scientific competence is most evident in the recent Galileo, Cassini, and UARS missions, and in on-going efforts to develop and perfect detector systems and other instruments.

Research and development programs at LASP provide new techniques for data manipulation and image processing, as well as new instruments and sensors for space applications. Members of LASP examine basic concepts for space operations and information systems and develop tools and approaches to evaluate and support these concepts. A number of the research associates at LASP hold joint appointments in the Department of Astrophysical and Planetary Sciences, in the Department of Atmospheric and Oceanic Sciences, in the Department of Physics, in the Department of Aerospace Engineering Sciences, and in the Department of Geological Sciences. The large scientific community at the University and in Boulder provides opportunities for members of LASP to enjoy substantial collaboration and communication with experts in related fields. LASP has also actively conducted experimental and theoretical work in cooperation with other universities in the United States and abroad. In recent years joint programs have been carried out with institutions in Belgium, Canada, Finland, France, Germany, Japan and Russia.

LASP has two facilities at the University of Colorado at Boulder. The LASP Campus facility is located in the Duane Physics Building. The LASP Space Technology Building, shown on the cover of this report, is located off-campus in the Research Park at 1234 Innovation Drive. The public is invited to tour our facility and to observe the work that LASP does today.

Please visit LASP’s Website for the latest developments and information on all of LASP’s sponsored programs: [http://lasp.colorado.edu](http://lasp.colorado.edu)

**A Message from the Director**

The present time is a period of tremendous growth and expansion for LASP. New scientific programs have been added and many new staff members have joined. We can point with pride to the successful designing, building, and testing of new spacecraft instruments (as reported in these pages) and we can also report on scientific results from many ongoing programs. Our combination of experiments, data analysis, and theoretical investigations provides for a remarkably complete scientific approach within LASP. Along with our incomparable engineering, mission operations, and information systems work, we believe that LASP is nearly unique in its abilities as a space research enterprise.

In order to carry out the wide range of work undertaken by the Laboratory, it has been clear for some time that more office and laboratory space has been (and certainly will be) necessary. We have asked the University administration for help to meet space needs. I am very pleased to report that we have been supported strongly by the Chancellor and the Provost to move aggressively toward meeting our “inner” space needs. We are now reaching a final design and the requisite approvals are nearly in hand to proceed with a new building adjacent to the...
present LASP Space Technology Building in the Research Park. This new facility will provide new space comparable in area to the present LSTR building and should allow us to move smoothly to the next level of engineering, operations, and science that we have been striving for.

There are many challenges that must be confronted as an organization grows. Adding new people and facilities while maintaining the traditional LASP “culture” is a top concern for all of us. I have appreciated the strong support and thoughtful advice in these matters both by the University administration and by our External Advisory Committee (chaired by Prof. L.A. Fisk). I have particularly appreciated the patience and good spirit of our tireless staff here at LASP.

We express our appreciation to the University, to the local Boulder community, and to the national agencies for the continuing support that we receive. We look forward to working actively with the broad space research community in many new endeavors. Thank you to the students, staff, and faculty of LASP for all their hard work. Special thanks go to Ann Alfaro for her thorough and thoughtful efforts in preparing this report.

Daniel N. Baker
**Research Support: 2003 Fiscal Year**

During the period 1/1/2003 to 12/31/2003 LASP appropriated funding totaled $33M for support of 147 grants and contracts.

<table>
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<th>Source of Funding</th>
<th>Total Grant Dollars</th>
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<td><strong>Totals:</strong></td>
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Science Spotlights

LASP's vision is to achieve world leadership status in identifying and addressing the key questions in planetary, atmospheric, and space sciences. We seek to continuously maintain and improve our capability to pursue these questions using experimental, laboratory, theoretical, and information systems approaches. We are dedicated to building and maintaining a unique synergism of expertise in space science, engineering, and spacecraft operations.
Solar Terrestrial Physics

Solar Radiation and Climate Experiment (SORCE)

SORCE Mission Description

The SOlar Radiation and Climate Experiment (SORCE) is a free-flying satellite carrying four instruments to measure the solar radiation incident at the top of the Earth’s atmosphere. SORCE was successfully launched on Saturday, January 25, 2003, from Kennedy Space Center (KSC) in Cape Canaveral, Florida. As one element of NASA’s Earth Science Enterprise, the SORCE mission is a joint effort between NASA and the Laboratory for Atmospheric and Space Physics (LASP). LASP has full programmatic responsibility for this 5-year mission to further understand the influence of the Sun on the Earth system.

The SORCE mission is under the direction of Principal Investigator Gary Rottman. LASP developed, calibrated, and tested the four science instruments, and integrated them onto a spacecraft provided by Orbital Sciences Corporation. The science and mission operations are conducted from LASP’s Mission Operations Center, and commands and data are communicated with the satellite twice per day (typical). All aspects of the mission are exceeding expectations, as the spacecraft and instruments continue to function flawlessly.

The primary science objectives of SORCE are to make daily measurements of Total Solar Irradiance, TSI, and spectral irradiance over almost the entire spectral range from soft X-rays, through the visible and into the infrared. The SORCE instruments – the Total Irradiance Monitor (TIM), the Spectral Irradiance Monitor (SIM), two Solar Stellar Irradiance Comparison Experiments (SOLSTICE), and the XUV Photometer System (XPS) – are currently measuring the Sun’s total and spectral irradiance with unprecedented accuracy and precision capable of establishing solar variability. In addition to securing a reliable database with which to characterize solar radiative forcing of climate and global change, the SORCE program seeks to foster new understanding of the origins of the solar variations and the physical pathways by which the Earth’s atmosphere, oceans and land respond, on multiple time scales.

SORCE Instruments

SORCE provides precise daily measurements of the TSI, as well as the spectral solar irradiance (SSI) at wavelengths extending from the far ultraviolet to the near infrared.

The TIM monitors changes in total incident sunlight to the Earth’s atmosphere via an ambient temperature active cavity radiometer. Imperative for climate modeling, this instrument reports the average daily value of the Sun’s radiative input at the top of the Earth’s atmosphere. The TIM’s state-of-the-art Electrical Substitution Radiometers (ESRs) measure TSI to an absolute accuracy of about 0.03%.

The newly developed SIM instrument incorporates an entirely different technique to make the first continuous record of the top of the atmosphere spectral solar irradiance in the visible/near infrared region. It uses a prism as the self-calibrating, single optical element and a miniature absolute ESR as the primary detector. This instrument has a measurement requirement of 0.03% absolute accuracy and precision and long-term relative accuracy of 0.01% per year. The SIM instrument measures spectral irradiance from 200 to 2400 nm. Understanding the wavelength-dependent solar variability is of primary importance for determining long-term climate change processes.
There are two identical SOLSTICE instruments on SORCE to measure spectral irradiance from 115 to 320 nm, with a spectral resolution of 0.1 nm. These instruments are an evolution and refinement of the Upper Atmosphere Research Satellite’s (UARS) SOLSTICE, and they observe the same bright blue stars as a long-term calibration standard. The stellar targets establish essential corrections to the instrument sensitivity, since these stars should remain absolutely constant. Previous solar measurements show that far ultraviolet irradiance varies by as much as 10% during the Sun’s 27-day rotation, while the bright 121.6 nm hydrogen Lyman–α emission may vary by as much as a factor of two during an 11-year solar cycle, dramatically affecting the energy input into the Earth’s upper atmosphere.

**Mission and Science Operations**

The SORCE satellite is orbiting the Earth every 90 minutes or 15 times daily. Ground stations at Wallops Island, Virginia and Santiago, Chile are providing the communication links to the satellite two times each day. The LASP Mission Operations Center (MOC) provides the computer hardware and software necessary to conduct real-time spacecraft operational activities, including command and control of the satellite, mission planning, and assessment and maintenance of spacecraft and instrument health. There are approximately 700 operational activities scheduled during a typical day.

The science operations from the MOC include experiment planning, data processing and analysis, validation, and distribution of the finished data product. By early March 2003, all instrument doors were open and science operations had begun. The first validated science data were received approximately two months after the launch.

Within 48 hours of data capture, all instrument science data and spacecraft engineering data are processed to derive Level 3 science data products in standard geophysical units (W/m² or W/m²/nm). The Level 3 data consists of daily and 6-hour average solar irradiances, with higher time resolution data available to meet secondary science objectives, such as studying the passage of bright faculae and dark sunspots across the visible surface of the Sun. All validated data are delivered to the Goddard Space Flight Center Earth Sciences DAAC (Distributed Active Archive Center) for distribution and long-term storage. All SORCE data are also available on the SORCE website: [http://lasp.colorado.edu/sorce](http://lasp.colorado.edu/sorce)
**Science Results**

SORCE SOLSTICE has twice the spectral resolution in the MUV as its predecessor, UARS SOLSTICE. This small piece of the solar spectrum shows the broad absorption and core emission features from single ionized Magnesium in the Sun’s outer atmosphere.

### Science Results

**SORCE Records Flare Activity**

During the last week of October and the first week of November 2003 the Sun surprised scientists with exceptionally high levels of activity. It is indeed fortuitous that SORCE was available to record the “fireworks” on the Sun. The extreme solar activity gave everyone a small reminder of how important it is to understand the Sun and how it influences the Earth.

The Sun was very active in 2001 to 2002, and it was generally felt that the Sun was well on its way back to its dormant state. Scientists were therefore quite surprised when new and intense magnetic activity appeared on the Sun. Indeed it is remarkable that several of the largest sunspots ever recorded appeared and moved across the solar disk during the week of October 26th.

When the Sun is active it is not unusual for intense flares and coronal mass ejections to occur. These transient phenomena carry large amounts of energy from the Sun to the Earth, and often cause havoc within our environment. The energy comes in two forms of radiation — light or electromagnetic energy and particles, primarily electrons and protons. When this transient energy reaches the Earth it interacts in quite different ways. These magnetically charged particles are so energetic that they easily pass through spacecraft shielding and often damage sensitive electronics causing satellite failures. In addition, the particles and fields energize the very outer regions of our atmosphere and cause radio communication interruptions. The intense fields generated by the particles can also couple energy to power grids at the Earth’s surface causing disruption and power outages.

The light radiation from the flare is also very intense, but only in very energetic X-rays (XPS) and far ultraviolet (SOLSTICE), and not in the visible light that reaches the surface of the Earth (TIM). This flare radiation is entirely absorbed in the upper layers of our atmosphere where it also ionizes the atmosphere to interfere with radio communication. Moreover, the intense radiation heats the atmosphere and causes it to expand. The expansion increases the atmospheric density at all altitudes, which in turn slows satellites causing them to fall prematurely.

The SORCE instruments have done a spectacular job capturing these recent flare incidents with great precision. These detailed measurements will be extremely useful to the solar physics community. For the TIM instrument, it is the first time that a TSI measuring instrument has ever seen a flare. SOLSTICE observed factors of two to ten increase in the ultraviolet while XPS recorded non-stop flare activity over many days. The SORCE scientists are thrilled to be fulfilling a dream, where
instrument measurements are exceeding expectations and the Sun is cooperating by providing a most serendipitous display of unpredictable power.

Outreach to the General Public

In preparation for launch, several SORCE public relations pieces were completed. Working with NASA, a glossy SORCE brochure was published along with a SORCE Science Writers’ Guide, a SORCE summary lithograph, and a SORCE CD-ROM. Working with LASP, NASA television producers completed a full public relations package, including videos, animations, and interviews for news media. NASA hosted a SORCE Press Conference, which included Gary Rottman, at Kennedy Space Center prior to launch, and had live coverage of the actual launch.

The LASP lobby has 4 new instrument photos, and a large 10’ wide by 7.5’ tall SORCE display outside the Mission Operations Center. The portable display features the spacecraft, instruments, and a science overview. LASP also created a SORCE poster and bendable cube, and continues to use the hands-on SORCE Sun Kit experiment for school outreach programs.

Press conferences and press releases have been on-going throughout this busy year. The releases have been on both the national and local level. A SORCE monthly newsletter also keeps people informed.

The SORCE website has become an extremely valuable resource for current information. The new look is very colorful and includes much more information. It is easy to maneuver, and meets the needs of the solar expert, non-technical person, and public educators teaching at many levels. Team members are producing a weekly SORCE status report to document progress during the mission. It summarizes the spacecraft activity, ground contacts, the instrument measurements, spacecraft and instrument planning, and data processing. The website is updated constantly with instrument data, science applications and animations, SORCE meetings and newsletters, photos, interviews, and interactive activities. For further information about SORCE, go to the website at: http://lasp.colorado.edu/sorce

SDO EUV Variability Experiment (EVE)

The Extreme ultraviolet Variability Experiment (EVE), being developed at LASP, is one of three scientific instruments on the NASA GSFC Solar Dynamics Observatory (SDO) spacecraft. The SDO mission, with a planned April 2008 launch, will be the first satellite for the new NASA Living With a Star (LWS) program. The SDO mission will study the solar magnetic fields and how they evolve, the dynamics of the solar atmosphere, the solar EUV irradiance and how it varies, and how solar eruptive events, including flares, proton storms, and coronal mass ejections, influence space weather phenomena, such as thermospheric density that affect satellite drag and ionospheric variations that affect communications. The EVE instrument will measure the solar EUV irradiance between 0.1 and 105 nm with 0.1 nm spectral resolution longward of 5 nm. The two EVE spectrograph systems are the Multiple EUV Grating Spectrographs (MEGS) (to be built at LASP) and the EUV Spectrophotometer (ESP) (to be built at the University of Southern California (USC)). A concept picture of the EVE instrument is shown below. LASP scientists involved with the SDO EVE program are Tom Woods (PI), Frank Eparvier, Gary Rottman, and Don Woodraska. EVE program manager: Mike Anfinson; EVE system engineers: Greg Ucker and Rick Kohnert; EVE lead engineers: Neil White (EE), Steve Steg (ME), Gail Tate (S/W), and Doug Vincent (QA).
**TIMED Solar EUV Experiment (SEE)**

The Solar EUV Experiment (SEE), built at LASP, is one of four scientific instruments on the NASA Thermosphere-Ionosphere-Mesosphere-Energetics-Dynamics (TIMED) spacecraft. The TIMED spacecraft was launched (NASA 36.205) on December 7, 2001, and the SEE instrument has made daily measurements of the solar vacuum ultraviolet (VUV: $\lambda < 200$ nm) irradiance since January 22, 2002. This highly variable radiation is one of the major energy sources for Earth's upper atmosphere and is fundamental for the TIMED mission's investigation of the energetics in the tenuous, but highly variable, layers of the atmosphere above 60 km. Changes in the amount of solar radiation, which range from 10% at the longer VUV wavelengths to factors as much as 10 or more at the shorter wavelengths, result in corresponding changes in the photochemistry, dynamics, and energy balance of the upper atmosphere. A detailed quantitative understanding of atmospheric radiative processes, including changes in the solar VUV irradiance arising from flares, solar rotation (27 day), and the 11-year solar cycle, is fundamental to the TIMED investigations. The primary science objectives for SEE are to accurately and precisely determine the solar VUV absolute irradiance and variability during the TIMED mission, to study the solar-terrestrial relationships utilizing atmospheric models, and to improve models of the solar VUV irradiance.

Some interesting results from TIMED SEE have been the measurements of more than 180 flares, most of them during the May-June 2003 and October - November 2003 solar storms. The later solar storm period is particularly interesting because the largest known X-ray flare (X28 class) occurred on November 4, 2003. An example of the SEE flare results is given in a movie located at:


On an annual basis, the prototype SEE instruments are calibrated at the NIST Synchrotron Ultraviolet Radiation Facility (SURF) in Gaithersburg, Maryland and then flown as a suborbital experiment as a way to track the sensitivity changes of the SEE instrument aboard the TIMED satellite. The latest calibration rocket launch was on August 12, 2003 from the White Sands Missile Range (WSMR) in New Mexico. The LASP group working on the rocket experiment, as shown in the following picture at the WSMR test area, are Phil Chamberlin, Ryan Keenan, Frank Eparvier, Alex Woods, Tom Woods, and Greg Ucker.

LASP scientists analyzing the TIMED SEE data are Tom Woods (PI), Frank Eparvier, Gary Rottman, and Don Woodraska. SEE flight operations staff includes Don Woodraska, Phil Chamberlin, Tom Woods, Karen Turk, Frank Eparvier, and Matt Kelly.
NASA’s Upper Atmosphere Research Satellite (UARS) was launched in September 1991, and is a mission dedicated to improving our understanding of ozone in the Earth’s middle atmosphere. The spacecraft carries ten instruments to measure the composition and structure of the middle atmosphere with additional instruments to collect information on atmospheric dynamics and energy input. Special emphasis has been given to the measurement of ozone and other key gases that influence ozone concentration and distribution.

The Sun is the dominant direct energy input to the middle atmosphere, and changes in the solar radiation, primarily ultraviolet radiation with wavelengths shorter than 300 nm, will lead to changes in atmospheric composition, temperature, and dynamics. To study atmospheric processes, for example those involving ozone photochemistry, the UARS observations include precise and reliable measurements of solar ultraviolet radiation. The UARS solar observations must be of sufficient quality and accuracy to allow valid comparisons to past and, especially, to future observations. The Solar Stellar Irradiance Comparison Experiment, SOLSTICE, was developed by LASP, and has been operated from an instrument control center on campus for the past thirteen years.

The SOLSTICE measures solar ultraviolet irradiance from 120 nm to 420 nm, with a spectral resolution better than 1 nm. In order to track changes in the instrument sensitivity, SOLSTICE – as its name implies – has the unique capability of directly observing stars with the very same optics and detectors used for the solar observations. These stars become the “standard candles” against which the Sun is compared, and assuming that the stars are constant over long time periods they provide a method of directly relating today’s UARS observations to all future solar measurements. The stability of the special stars (early type O, B, and A) selected for comparison is a reasonable assumption based on the theory of stellar evolution.

Solar radiation was at high levels early in the UARS mission, decreased to low values in 1996, regained the higher levels seen early in the mission, and has now once again decreased toward lower values. In addition to this longer term, solar-cycle variability, the data also display a striking higher frequency variation with a period of about 27 days – the rotation period of the Sun. Both types of variation are related to the storage and release of magnetic energy in the Sun. The UARS SOLSTICE data are widely used by the scientists studying atmospheric processes and climate, and by those studying the Sun as the source of the varying radiation.
At 9:34 AM UT on Saturday, December 13, 2003, the Student Nitric Oxide Explorer (SNOE) completed nearly six years of continuous observation and reentered the Earth’s atmosphere. SNOE remained fully functional throughout its mission and was still making observations during the final possible contact. Reentry was a natural consequence of its six years in low Earth orbit.

The primary goals of SNOE were to determine the magnitude and variability of nitric oxide in the lower thermosphere and to determine the relationship between NO and the energetic inputs to the atmosphere that create it. SNOE far exceeded expectations. SNOE observations confirmed previously held suspicions that the solar soft X-ray irradiance was stronger than the prior sparsely-available data and empirical models suggested. SNOE demonstrated that solar soft X-ray irradiance and auroral energy deposition control the abundance of NO over the globe, but provided the very surprising results that wintertime midlatitude NO is controlled by auroral energy while summertime polar NO is controlled by solar irradiance. The morphology of NO also provided clues to the processes in the magnetosphere that lead to the auroral energy deposition. And finally, serendipitous observations of polar mesospheric clouds by SNOE provided an excellent database for climatological studies of these clouds, showing that there is a strong hemispheric asymmetry in their distribution and that they are strongly influenced by local dynamics.

Many students contributed greatly toward SNOE’s design, development, testing, launch, operations, and data analysis. SNOE was managed for NASA by the Universities Space Research Association (USRA) under the Student Explorers Demonstration Initiative (STEDI). The goal of STEDI was to show that small relevant research satellite missions could be developed at low cost and with high educational benefit by giving students a large involvement. SNOE was developed and operated through its primary mission for less than $5M (less launch vehicle costs). The SNOE development team consisted of over 120 students working closely with a small number of experienced professionals. Students had significant responsibilities in all areas of the mission.

SNOE benefited greatly from support and collaboration from throughout the community: USRA, NASA, NCAR, SwRI, Ball Aerospace, the TIMED community, the Geophysical Institute and Alaska SAR Facility at the University of Alaska. Data may be obtained from the SNOE websites as well as the NSSDC. For more information about SNOE, visit lasp.colorado.edu/snoedata and snoe.gi.alaska.edu.

Measurements of Halogen Oxides in the Troposphere

Ozone depletion events occur not only in the stratosphere (the Antarctic “ozone hole”), but also near the Earth’s surface at high latitudes in springtime. Although the mechanism for these boundary layer ozone losses is not completely understood, it is believed that they are caused by enhancements in reactive gas-phase bromine species, which may originate in sea-salt. As part of the Alert 2000 Polar Sunrise Experiment in Alert, Nunavut, Canada during April-May 2000, the radical species chlorine oxide and bromine oxide (ClO, BrO) were measured using vacuum ultraviolet resonance fluorescence techniques. The results from this study indicate that snow-covered surfaces near the Arctic Ocean are indeed sources of atmospheric bromine.

Members of Linnea Avallone’s research group traveled to McMurdo Station, Antarctica in August-October 2002 to study halogen chemistry in a remote, unpolluted location. The results of this research were quite surprising: local pollution (from vehicles and the power plant) contributes significantly to changes in the ozone abundance, as do large storms traveling off the Antarctic continent. Further, the bromine chemistry seems to be unlike that seen in the Arctic. A second trip is planned in fall 2004 to continue our research there, with a fo-
focus on understanding the impacts of local pollution and the snow/ice surface on ozone amounts. For further information, please see the website:

http://lasp.colorado.edu/programs_missions/present/halogenoxide.html.

**Cirrus Cloud Ice Water Content**

Understanding the interaction of clouds with solar and terrestrial radiation is an important research goal, in light of the significance of clouds in the Earth's energy balance and the possibility that cloud properties will change as climate changes. Accurate knowledge of the amount of water condensed in clouds - ice water content (IWC) and ice water path (IWP) - is important for retrieving cloud parameters from space-borne instruments, and for modeling the radiative properties of clouds.

Linnea Avallone's research group has developed a technique for determining the water content of particles in cirrus clouds. A closed-path tunable diode laser hygrometer is coupled to a heated, subsokinetic inlet to measure the amount of water condensed in particles with diameters larger than about 4 micrometers. Although smaller particles are also sampled, the instrument's sensitivity to them is low. These measurements are used, along with observations of water vapor made by a similar instrument operated by the Jet Propulsion Laboratory, to understand the fraction of water present in the condensed phase in a variety of cirrus cloud types.

The group participated in the NASA CRYSTAL-FACE campaign, making measurements of particulate water from the NASA WB-57F aircraft in a variety of cirrus: thunderstorm anvils, aircraft contrails, and so-called subvisual cirrus. The instrument has demonstrated a remarkable sensitivity, with a detection limit of less than 0.1 mg of condensed water per cubic meter of air. The observations obtained during CRYSTAL-FACE were used to gain a better understanding of the relationships among cloud IWC, particle sizes, and cloud radiative properties. Participation in NASA’s Mid-latitude Cirrus Experiment (MidCiX) focusing on direct comparisons of in situ and remote measurements of midlatitude cirrus clouds, is planned for April/May 2004. For more information, please see the website:

http://lasp.colorado.edu/programs_missions/present/crystal_face.html.

**Aeronomy of Ice in the Mesosphere (AIM)**

The Aeronomy of Ice in the Mesosphere, or “AIM”, experiment is a NASA Small Explorer mission designed to study Polar Mesospheric Clouds (PMCs), the highest clouds in the earth’s atmosphere – clouds at the edge of space. Dr. James Russell, III, from Hampton University, is the AIM principal investigator, and LASP scientists Mihaly Horanyi, Bill McClintock, Cora Randall, David Rusch, and Gary Thomas are co-investigators. LASP is also building two of the AIM instruments, as well as assuming the program management (led by Mike McGrath) and satellite operations (led by Randy Davis) roles. PMCs are made of frozen water, or ice crystals, and form at the polar summer mesopause, around 83 km above the earth’s surface. From the ground, these clouds can only be seen near twilight, when the sun is just below the horizon and the sky is dark. For this reason, they are often called “noctilucent” clouds, or NLCs, because the word noctilucent means “night-shining”. PMCs, or NLCs, usually form only at high latitudes near the north and south poles. In recent years, however, several people have reported seeing NLCs at lower latitudes, even as low as 40°N in the continental United States, in Utah and Colorado. Also, NLCs seem to be getting more numerous and brighter over time. The AIM experiment will probe the behavior of PMCs to determine if these changes are caused by natural variations in the earth’s at-
mosphere, or if they are influenced by human activities.

AIM is designed to discover how and why PMCs form and why they change. To accomplish this, the satellite will have three instruments that provide information about PMCs and their environment. The first instrument, CIPS (Cloud Imaging and Particle Size), will take pictures of the clouds to determine when and where they form, and what they look like; this instrument is being built at LASP, with David Rusch as its PI. The second instrument, SOFIE (Solar Occultation For Ice Experiment), will measure the temperature of the mesosphere and how much water vapor is present, to determine what combination of these is necessary to freeze the water into ice crystals that form PMCs. This instrument will also measure the amounts of other gases to tell scientists more about the chemistry and movement of air in the mesosphere that might lead to cloud formation or evaporation. SOFIE is being built at the University of Utah’s Space Dynamics Laboratory. The third instrument, CDE (Cosmic Dust Experiment), measures how much dust from meteors enters the earth’s atmosphere. This is important because scientists wish to find out if meteoric dust forms condensation nuclei, providing surfaces on which water vapor condenses and freezes; it is possible that without dust, PMCs are much less likely to form. CDE is also being built at LASP, with Mihaly Horanyi as its PI.

NLCs are intriguing clouds that inspire awe and wonder in those people lucky enough to observe them. Observations in the last decade suggest that it is more and more likely that even people in the continental United States and southern Europe will be able to see NLCs from their own backyards. The AIM mission will explore these clouds at the edge of space to solve their mysteries. AIM is currently entering into Phase C/D, set for a launch in September of 2006 for a 2-year mission.

For more information, please see: http://aim.hamptonu.edu/partners/3partner.html

**PLANETARY PHYSICS**

**Mechanics of Granular Materials (MGM)**

The MGM program investigates the behavior of granular materials at very low confining stresses. MGM is a fundamental research program that also has direct applications to life on Earth and to the exploration of other planets. In particular, the results of MGM research shed new light on the load-bearing capacity of soils in low-gravity conditions, and on the behavior of soil under low frequency vibration such as in earthquakes. MGM provides both theoretical models and experimental verification of those models through experiments performed in microgravity aboard the Space Shuttle.

MGM is a collaborative program between Principal Investigator Stein Sture of the University of Colorado’s department of Civil, Environmental and Architectural Engineering and a LASP team of professionals and students that provides science support, flight hardware and software development, mission operations and data analysis.

In January 2003 MGM was launched aboard Columbia for STS-107, its third space flight mission. A total of 10 experiments were performed in microgravity during the flight. Downlink data provided both real-time views of the experiments and an invaluable record for later analysis. Uplink commanding allowed the MGM team to fine-tune the experiments in flight to optimize performance. For this mission the MGM team had devised a new technique for reforming experiment specimens in microgravity. This technique made it possible to perform multiple experiments on a single specimen. More importantly, it allowed the team to create specimens with very low densities, too low to survive launch loads.
The tragic loss of Columbia and her crew also claimed the MGM flight experiment hardware. Data recorded from the live downlink have been augmented by the fortunate recovery of two MGM flash memory cards among the re-entry debris. Data analysis from the STS-107 mission is still in progress, but some key results have emerged. First, drained tests on water-saturated specimens confirmed the results of previous MGM flight experiments on dry specimens, showing that classical soil mechanics models have underestimated the strength of granular materials at low confining stresses. Dr. Susan Batiste of LASP has proposed an innovative model explaining the higher-than-expected strength, based on computed tomography scans of MGM specimens. Second, because the STS-107 flight experiment parameters could be modified in real time, the MGM team was able to explore the boundary conditions that induce liquefaction in soil, a key contributor to earthquake damage on Earth.

**Cassini UltraViolet Imaging Spectrograph (UVIS)**

LASP built the UltraViolet Imaging Spectrograph for the Cassini orbiter spacecraft, part of the NASA-ESA mission to Saturn. It was launched in October 1997 and will arrive at Saturn on June 30, 2004. The instrument is working well and on the way to Saturn. We are analyzing observations of stars, Venus, and the Earth’s Moon from 1999, and from Jupiter in 2000.

The LASP UVIS was built with the participation of the Max Planck Institute of Lindau, Germany. It measures the composition of the atmospheres of Saturn and Titan, their clouds, thermospheres, and heavy hydrogen abundances. Dynamical waves and wakes in the rings of Saturn and the upper atmospheric structure will be measured by observing stellar and solar occultations.

The Cassini spacecraft (2,500 kilograms of hardware and 3,000 kilograms of propellant) will deliver the European-built Huygens probe to Saturn’s moon Titan and then tour the Saturnian system for nearly four years.

Approximately 1,300 academic and industrial partners in 16 European countries are participating in the Cassini mission. In addition, there are more than 3,000 participants in 32 different states in the US. The mission is managed for NASA by the Jet Propulsion Laboratory in Pasadena, California, and for ESA by the European Space Technology and Research Center in Noordwijk, the Netherlands. The Italian Space Agency contributed the orbiter’s 4-meter-diameter high-gain antenna for communications and portions of other orbiter science experiments. The United States supplied batteries and two science instruments for Huygens.

In 2000, Cassini observed Jupiter, its atmosphere, moons, and glowing Io torus. These observations complement and extend those from the LASP Galileo UVS. In December 2003, UVIS began regular observations of the Saturn system on approach. Some of our first data are shown in the figure below.

The figure shows the distribution of atomic hydrogen emission in the Saturn system obtained using the UVIS FUV imaging spectrometer experiment. The observations provide the first spectral image from the Cassini Observatory Period. The data was accumulated December 25, 2003.
through January 6, 2004, at an average range of 85 Mkm from Saturn. The image definitively establishes the distribution of atomic hydrogen in the magnetosphere as a vast mass distributed asymmetrically in local time. The (false) view shown in the image is from above the South Pole with local west to the right. The sub-spacecraft point on Saturn was 20° S latitude and 62° solar phase angle. The sunlit atmosphere is on the right side of the figure. The primary properties of the distribution evident in the image are the extremely broad distribution in the orbital plane measurable to at least 45 Saturn radii from planet to center (Rₛ), and the extreme extent in latitude evidently significantly beyond 8 Rₛ above and below the poles. The distributional asymmetry and increasing abundance toward the planet is indicative of a source of energetic hydrogen at the top of the Saturn atmosphere. The abundance shows a sharp shelf on the western side at 25 Rₛ approximately at the location of the solar wind bow shock. This may be an indication of a cold out-flowing hydrogen component from Titan. In this view, there is no sign of the presence of an orbiting torus of hydrogen gas. A complete determination of distribution will require observations from different lines of sight, to be obtained later in the Saturn Tour. The signal shows a peak at the south pole of the planet, generated by auroral precipitation. A secondary peak appears from the dayglow in the sunlit atmosphere. The emission from the magnetosphere is caused by fluorescence of solar radiation. The pixel spatial resolution is 1.4 Rₛ in the east-west direction, and 2. Rₛ (interpolated) in the north-south direction.

The LASP UVIS Science team includes Principal Investigator Larry Esposito, Co-Investigators George Lawrence, Bill McClintock, Charles Barth, Joshua Colwell, and Ian Stewart. Alain Jouchoux is the Operations Team Leader, assisted by Michelle Kelley and Darren Osborne. For further information, please visit the website: http://lasp.colorado.edu/programs_missions/present/off_site/cassini.html

**Mars Landing Sites**

The Mars group has been playing a significant role in determining the geological characteristics and the processes responsible for them at spacecraft landing sites on Mars. This effort has centered primarily on analysis of spacecraft remote-sensing information pertinent to the surface thermophysical properties, their interpretation, and use in landing site selection and analysis. These efforts make use of observations from infrared instruments on board the Mars Global Surveyor and Mars Odyssey spacecraft, which our group has been taking the lead in analyzing and interpreting.

We have been using these data as members of the Landing Site Working Group for the Mars Exploration Rover missions, and participated in the process by which the final landing sites were selected. Since then, we have been doing more-detailed analysis of the properties of the two actual landing sites; this will complement the in situ analysis from the rovers themselves, and will allow us to extrapolate the observations of the physical properties of these sites to elsewhere on the planet.

The following figure is a thermal inertia map of the Meridiani landing site for the Opportunity rover. Colors represent different values of thermal inertia, most closely related to day-night temperature variation and due to different physical structures at the 10-cm scale. The large variability from place to place indicates variations in properties that are important for landed spacecraft and for interpretation of spacecraft data.
**Student Dust Counter (SDC)**

Dust disks around other stars (like Beta Pictoris or Epsilon Eridani) display complex structures that are thought to be the telltale signs of planets hidden inside. The recent discoveries of dozens of planets around other stars are observationally biased to Jupiter sized objects close to the central star. There is a strong desire to verify that the observed structures are indeed generated by smaller and more distant planets in these systems. There is now such an opportunity with the New Horizons (NH) mission to Pluto. The spacecraft will carry a dust instrument, the Student Dust Counter (SDC), to map the dust distribution in our Solar System in order to verify the existence of the predicted structures in our own disk, the Zodiacal dust cloud. SDC is a unique instrument; it will be designed, built, tested and operated by generations of students at LASP as part of the Education and Public Outreach effort of NH.

Though the dust counter is part of the mission’s education and public outreach program - rather than the main science payload - it will in fact contribute significant science. Because no dust detector has ever flown beyond 18 astronomical units from the Sun, the Student Dust Counter's data will be as valuable to researchers as the project's outreach focus is to students. The Student Dust Counter Team is shown in the image above.

SDC is based on a simple, reliable detector technology, using a 28 micron thin, and permanently polarized polyvinylidene-fluoride (PVDF) film. When a dust particle impacts on the detector it creates a local depolarization of the PVDF which creates a small charge imbalance across the film. The magnitude of this charge imbalance is proportional to the mass of the dust particle and how fast it was moving compared to the spacecraft. The instrument’s analog and digital electronics analyze and store the impact data for later retrieval by the spacecraft.

![Figure: The sensitivity of a single PVDF sensor was tested as function of its temperature at the Heidelberg, Germany dust accelerator facility. Shown here is one of the SDC detectors with its temperature controls inside the target chamber.](image)

The detector and electronics have been built to standard space flight quality in anticipation of returning data for many years. The New Horizons Mission is scheduled to launch in January 2006 and it will fly by Pluto and its moon, Charon, as early as 2015. It then would continue to explore multiple objects in the Kuiper Belt starting in about 2017. SDC will be delivered in the summer of 2004.

![Figure: The mechanical configuration of the SDC/CDE instruments. SDC will map the dust distribution in our Solar System from 1 to >50 AU, while CDE will monitor the dust influx into the Earth’s atmosphere. The Cosmic Dust Experiment (CDE) is part of the Aeronomy of Ice in the Mesosphere (AIM) Mission.](image)

For further information, please see: [http://lasp.colorado.edu/programs_missions/present/off_site/sdc.html](http://lasp.colorado.edu/programs_missions/present/off_site/sdc.html)
**Jupiter Magnetospheric Explorer (JMEX)**

**Mission Overview:**

- JMEX is an Earth-orbiting UV observatory viewing Jupiter when $\geq 45^\circ$ from the Sun and not occulted.
- JMEX provides continuous, long-term observations of Jupiter’s complex and dynamic system for two 9-month periods within the 24-month mission lifetime.
- Guest Investigators may use JMEX’s unique FUV and EUV capabilities when Jupiter is $\leq 45^\circ$ from the Sun.
- Mission operations are conducted by the University of Colorado with extensive student participation.

**Mission Summary:**

- Launch Date: January 2008
- Launch Vehicle: Pegasus XL
- Duration: 24 months
- Orbit: 600 km, 28.5º inclination
- Spacecraft Mass: 277.9 kg
- Communication: S-band, USN
- Total Cost: $120M

**Education and Public Outreach:**

- Taps public excitement surrounding volcanoes and the northern lights, integrating JMEX science into both formal and informal venues.
- Special emphasis on reaching underserved communities.
- LASP leads E/PO in collaboration with the science team, the National Center for Atmospheric Research, the Denver Museum of Nature and Science, and Passports to Knowledge.

**JMEX Spacecraft Characteristics**

- Ball’s RS300 uses heritage structural design, along with flight-proven components to enable low-cost production of a highly-capable design with margins.
- Reaction wheel vibration isolators reduce high frequency jitter.
- Feedback from Image Motion Sensor provides real-time input to observatory pointing control.
- 1-axis deployable solar panel provides high power margin throughout the mission.
- Materials, processes, and handling provide a non-contaminating environment for UV optics.
JMEX addresses major issues in NASA’s Sun-Earth Connections theme through a comparative magnetospheres study of the Jupiter-Io System. JMEX will answer four fundamental questions:

- Which processes in Jupiter’s magnetosphere are influenced by the solar wind (as at Earth), and which processes are controlled by Io?
- Does plasma production depend on Io’s volcanic activity, or is it controlled by Io’s magnetospheric interaction?
- How does the magnetosphere respond to internal plasma production?
- What are the causes of Jupiter’s three aurora? How are these processes similar to Earth’s and how do they differ?

**JMEX Observations:**

The Jupiter-Io system is highly variable and strongly coupled, so JMEX takes a unique approach with:

- Simultaneous, global, long-term measurements of Io, the plasma torus, and Jupiter’s aurora.
- An emphasis on discovering the cause-and-effect relationships between them.

**Science Team:**

Principal Investigator: Nicholas Schneider, U. Colorado  
Project Scientist: John Clark, Boston U.  
Fran Bagenal, CU/LASP  
Daniel Baker, CU/LASP  
Jack Connerney, GSFC  
Robert Ergun, CU/LASP  
Jean-Claude Gérard, LPAP/Ulg  
Randy Gladstone, SWRI  
Denis Grodent, LPAP/Ulg  
Floyd Herbert, U. Arizona  
William McClintock, CU/LASP  
Melissa McGrath, STScI  
Dusan Odstrcil, NOAA  
Pierre Rochus, CSL  
Stan Solomon, NCAR  
John Spencer, Lowell Obs.  
Hunter Waite, U. Michigan  
Philippe Zarka, Obs. de Paris

**Science Payload:**

- The FUV system (UVI) offers imaging and spectroscopy of Io, Jupiter’s aurora and atmosphere in the 115-200 nm range.
- The 50-cm FUV-optimized telescope yields $\leq 0.2$" optical image quality.
- An image Motion Sensor enables innovative jitter mitigation through post-processing, providing $\leq 0.25"$ final image quality.
- A 30-cm EUV telescope (EUVS) provides 64-114 nm spectral imaging of the Io plasma torus.
MErcury: Surface, Space ENvironment, GEOchemistry, and Ranging (MESSENGER)

The Mariner-10 flybys of the planet Mercury in 1974 and 1975 found a strong magnetic field and an active magnetosphere similar in many ways to that of Earth. Given the small size of the planet, Mercury’s interior was expected to have cooled and solidified long ago. The presence of an intrinsic magnetic field, however, implied an internal dynamo in a fluid core, posing numerous, unresolved questions concerning the origin, composition, and thermal history of Mercury. The Mariner-10 spacecraft also detected intense particle bursts and magnetic field disturbances, indicating that magnetospheric substorms occur at Mercury.

The MESSENGER mission was developed in the NASA Discovery Program. This mission to Mercury will provide unique measurements that are not possible at other planets due to the constraints of orbital mechanics and the large dimensions of other magnetospheres relative to their planetary bodies. The MESSENGER mission will provide the essential data necessary to formulate the next generation of theories and models for terrestrial-type planetary structure and dynamics. The mission will also return critical measurements necessary for the understanding of not just the surface history and internal structure of Mercury but the formation and chemical differentiation of the Solar System as a whole.

MESSENGER is a large collaboration of 11 different institutions. It is led by Sean Solomon from the Carnegie Institution in Washington, DC and managed by the Applied Physics Laboratory at the Johns Hopkins University. MESSENGER will be launched in August 2004. It will study the planet’s surface morphology and composition, interior structure and magnetic field, and atmospheric and magnetospheric composition. Included in this suite is the Mercury Atmospheric and Surface Composition Spectrometer (MASCS), which will be designed, built, and operated by the Laboratory for Atmospheric and Space Physics. William McClintock and Daniel Baker are both Co-Investigators on the MESSENGER science team. For more information, please visit the MESSENGER website:
http://lasp.colorado.edu/programs_missions/present/messenger.html

Figure: The MASCS detector package that is being prepared for MESSENGER by LASP researchers.
Astrobiology

The CU Center for Astrobiology has been a member institution of NASA’s Astrobiology Institute since the latter was formed in 1998. This past year, we were selected again as a member to continue for the next five years. The CU effort is intended to be a broad one, addressing scientific issues across all of the disciplines that pertain to understanding life in the universe. It includes research in the early history of the Earth, the origin of life, and the evolution of life here on Earth; in the formation and evolution of our solar system and of the planets that comprise it, of the resources available to support possible life there, and the occurrence of environments that could support life; and of the formation and evolution of planets beyond our own solar system, orbiting other stars, and the potential they might have to support life. In addition, we have involvement from outside of the sciences, with participation in the area of philosophy of science.

The astrobiology effort is centered within LASP, but also includes faculty, research, and teaching in Geological Sciences, Atmospheric Sciences, Planetary Science, Astrophysics, Molecular Biology, Evolutionary Biology, Biochemistry, and Philosophy. Within LASP, faculty who are participating include Bruce Jakosky (with research on Mars climate evolution and biological potential), Brian Toon (climate processes and the role of aerosols in particular), Bob Pappalardo (icy satellite geology and geophysics, and potential for life), Tom McCollom (terrestrial and planetary environments capable of supporting life, and geochemical energetics).

In addition to a research program that is cutting edge across all of the disciplines that comprise astrobiology, the Center for Astrobiology supports a vigorous education and public outreach program in astrobiology. Efforts include public symposia on topics of interest (most recently, dealing with the scientific results from the recent Mars missions), public events (such as the open houses held recently at LASP), and the first in what will become a series of symposia held for science journalists as professional development in understanding complex issues in astrobiology. For further information, please go to: http://lasp.colorado.edu/programs_missions/present/off_site/astrobiology.html.
**SPACE PHYSICS**

*Time History of Events and Macroscale Interactions during Substorms (THEMIS)*

THEMIS is a five-satellite mission with the job of determining the causes of the global reconfigurations of the Earth's magnetosphere that are evidenced in auroral activity. The mission, to be launched in spring/summer 2006, consists of 5 small satellites, each carrying identical suites of electric, magnetic, and particle detectors, that will be put in carefully coordinated orbits. Every four days the satellites will line up along the Earth's magnetic tail, allowing them to track disturbances. The satellite data will be combined with observations of the aurora from a network of observatories across the Arctic Circle.

THEMIS will answer fundamental outstanding questions regarding the magnetospheric substorm instability, a dominant mechanism of transport and explosive release of solar wind energy within Geospace. Its primary goal is to elucidate which magnetotail process is responsible for substorm onset at the region where substorm auroras map: (i) a local disruption of the plasma sheet current at a distance of about 10 Earth radii or (ii) that current's interaction with the rapid influx of plasma emanating from magnetic reconnection at ~25 Earth radii. While this question has long been at the forefront of substorm research, THEMIS is the first mission to directly target this topic with the combined multisatellite and ground-based approach that is needed for its resolution.

THEMIS's five identical probes measure particles and fields on orbits that optimize tail-aligned conjunctions over North America, where ground observatories can observe the substorm auroral breakup. Three inner probes at ~10 Earth radii monitor current disruption onset, while two outer probes, at 20 and 30 Earth radii respectively, remotely monitor plasma acceleration due to lobe flux dissipation. In addition to addressing its primary objective, THEMIS answers critical questions in radiation belt physics and solar wind - magnetosphere energy coupling.

Principal Investigator for the THEMIS mission is Dr. Vassilis Angelopoulos of the University of California, Berkeley. Dr. Robert Ergun of LASP is responsible for building the Digital Fields Board (DFB), an on-board unit that digitally processes the signals from the electric fields and the magnetic search coil experiments to yield flexible, scientifically useful products. Examples of the DFB functionality include the ability to measure the wave spectrum of electromagnetic waves, and the ability to digitally "rotate" the measured quantities to align them with the local magnetic field. In addition to Dr. Ergun, the LASP group working on building the DFB consists of Jim Westfall, Ken Stevens, Aref Nammari and Chris Cully. Dr. Xinlin Li will also be extensively involved in the analysis of data once the mission is flying.

For further information, please see: [http://sprg.ssl.berkeley.edu/themis/](http://sprg.ssl.berkeley.edu/themis/)
Solar, Anomalous, and Magnetospheric Particle Explorer (SAMPEX)

SAMPEX carries a payload of four scientific instruments which study solar particles, anomalous cosmic rays, and magnetospheric electrons and ions. It has been operating in low-Earth orbit since July 1992. The SAMPEX instruments have sensitivities >100 times greater than previous spacecraft, and these have led to new discoveries such as a new radiation belt of interstellar material and rare hydrogen and helium isotopes trapped in the radiation belts. SAMPEX continues to provide unique global maps of magnetosphere energetic particles, and has given new insights into the processes by which radiation levels through the entire magnetosphere can become greatly enhanced.

The figure below shows how the SAMPEX mission fits into the broad sweep of other active space physics missions. It is likely that SAMPEX could continue to operate for several more years until it re-enters the Earth’s atmosphere.

LASP scientists Daniel N. Baker, Xinlin Li, and Josh Rigler are working on magnetospheric data from SAMPEX. New results have been obtained by comparing relatively low-energy (E>25keV) electrons measured by SAMPEX with SNOE measurements of nitric oxide in Earth’s upper and middle atmosphere. This collaborative work is being carried out with Charles Barth. For further information, please see: http://lasp.colorado.edu/programs_missions/present/sampex/

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Studying the Solar-Terrestrial Particle Chain
Center for Integrated Space Weather Modeling (CISM)

CISM, the Center for Integrated Space Weather Modeling, is a multi-institution National Science Foundation (NSF) Science and Technology Center (STC) based at Boston University. The vision of the institution is to understand our changing sun and its effects on the solar system, life, and society by creating a physics-based numerical simulation model that describes the space environment from the Sun to the Earth. The Knowledge Transfer and Forecast Model branch of the center is based at LASP and led by Daniel N. Baker; participating scientists and students include Scot Elkington, Alexa Halford, Manny Presicci, Josh Rigler, Robert Weigel, and Xinlin Li.

The figure below is a composite image showing types of simulation codes and regions in which they will be linked. The solar corona and solar wind MHD codes (A) will track the influence of the Sun to the magnetosphere where a global MHD code (B) will compute the interaction between the solar wind and the magnetosphere and will form the spine of linked codes. The ring current will be computed using the RCM (C). Particle and hybrid codes (D) will be used to model the reconnection physics. The TING code (E) will model with ionosphere and thermosphere. Further information about CISM can be found at: http://www.bu.edu/cism/
**Education and Public Outreach**

LASP’s education program took on new dimensions this year with coordinated efforts in both Space Weather and Astrobiology. With support from the Applied Physics Laboratory at Johns Hopkins University (as part of the TIMED/SEE mission), we invited Fiske Planetarium to develop a new show on Space Weather, due to debut in August of 2004. Additional components of the program have been funded by NASA OSS E/PO add-ons to grants awarded to Dr. Fran Bagenal and Dr. Xinlin Li. The funds support both teacher professional development workshops on space weather, as well as TV-based distance learning programming produced by the NASA Distance Learning Center at NASA Langley. LASP E/PO is also supporting a Spanish version of the planetarium show out of general funds.

LASP, in conjunction with CU’s Center for Astrobiology and Center for Environmental Journalism, hosted a 2-day workshop for journalists from around the country in advance of the MER and Beagle-2 missions. Eighteen journalists and nine scientists and educators converged on LASP to explore Mars system science, the MER landings and the future of astrobiology and Mars exploration. The workshop was funded as part of the Center for Astrobiology’s E/PO efforts for the NASA Astrobiology Institute and served as a trial balloon for professional development of media professionals.

LASP is enjoying a greater recognition in the community, largely due to the outstanding efforts of Heather Reed and the engineering staff. We gave tours to more than 20 different groups (children and adults), reaching over 400 people. As important, we are streamlining and formalizing the tours, as well as increasing the number of engineers participating in them. LASP staff also volunteered to be judges at science fairs, mentors for high schools students, and giving talks in local schools.

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**LASP Faculty**

**Daniel N. Baker**  
Director

Laila Anderssen  
Linnea M. Avallone  
Frances Bagenal  
Charles A. Barth (Ret.)  
David Brain  
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William Emery  
Francis G. Eparvier  
Robert Ergun  
Stefan Eriksson  
Larry W. Esposito  
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Robert E. Grimm  
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A. Ian F. Stewart  
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O. Brian Toon  
Robert Weigel  
Thomas N. Woods
Visiting Scholars

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Dr. Scott M. Bailey, University of Alaska at Fairbanks
Dr. Greg Berthiaume, MIT Lincoln Laboratory
Dr. Andrew Jones, University of Southern California
Dr. Darrell Judge, University of Southern California
Dr. Antal Juhasz, Research Inst. for Particle and Nuclear Physics, Hungary
Dr. Mark Lewis, Trinity University, San Antonio, Texas
Professor Kap-Soo Oh, Chungnam National Univ., Daejeon, South Korea
Dr. Robert McPherron, University of California, Los Angeles
Dr. Tai D. Phan, Space Sciences Laboratory, University of California at Berkeley
Dr. Roger J. Phillips – Washington University, St. Louis, MO
Dr. Chao Shen, Chinese Academy of Sciences, Beijing
Dr. Barbara Thompson, NASA Goddard Space Flight Center
Dr. Kent Tobiska, Space Environment Technologies

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Bryce Bolton  David Gathright  Sherry McGlochlin  Janet Tracy
Brian D. Boyle  Michael Gehmeyr  Michael McGrath  Matt Triplett
John Boynton  Vanessa George  James Mack  Gregory Ucker
Shelley Bramer  Judith (Dede) Gleason  Melanie McKinney  Douglas Vincent
James Brault  Ken Greist  Karen M. MacMeekin  Jeffrey Weber
Nancy Brooks  Bonnie Kae Grover  Ken Mankoff  Paul Weidmann
Shawn Brooks  Roger Gunderson  Jack Marshall  James Westfall
Jeff Brown  Scott Gurst  Willie Mein  Neil White
Patrick Brown  Christine Hathaway  Russel Meizner  Ann Williams
Michael T. Callan  Karl Heuerman  Nathaniel Miller  Dave Wilson
Zachary Castleman  Meredith Higbie  Steve P. Monk  Ann Windagel
Zhangzhao Chen  Caroline Himes  Aref Nammari  Heather R. Withnell
Wesley Cole  Rose A. Hoag  Toan Nguyen  Peter Withnell
Lillian Connelly  Timothy Holden  Sara Orhtman  Donald Woodraska
David Crotser  Bonnie W. Hotard  Chris Pankratz  Mia Woody
John A. Daspit  Vaughn Hoxie  Nicole Ramos  Ed Wullschleger
Randall L. Davis  Andrew Hunt  Thomas Reese  Alan Yehle
Kip W. Denhalter  James Johnson  Randy Reukauf  Jason Young
Lindsay DeRemer  Alain J. Jouchoux  Pat Ringrose  Steve Zdawczynski
John Donnelly  David E. Judd  Timothy Ruske  Torsten Zorn
Sharon Dooley  Ryan Keenan  Marissa Rusinek  Ann Williams
Michael Dorey  Michelle Kelley  Cynthia Russell  Dave Wilson

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2003 Graduates

Shawn M. Brooks, Ph.D., Astrophysical, Planetary, and Atmospheric Sciences
Dec 2003
“Jupiter’s Ring System Revisited: A deeper understanding from Galileo visible and infrared imaging”
Thesis Advisor: Larry W. Esposito

Matthew H. Burger, Ph.D., Astrophysical, Planetary, and Atmospheric Sciences
May 2003
“Io’s Neutral Clouds: From the Atmosphere to the Plasma Torus”
Thesis Advisor: Nicholas M. Schneider

Amelia M. Gates, Ph.D., Astrophysical, Planetary, and Atmospheric Sciences
Dec 2003
“Airborne in situ measurements of carbon dioxide: Instrument development and applications to rocket plume chemistry and dynamics”
Thesis Advisor: Linnea Avallone

Anna Gannet Haller, Ph.D., Astrophysical, Planetary, and Atmospheric Sciences
Dec 2003
“Use of tunable diode laser closed path hygrometer for the measurement of total water in tropopause cirrus”
Thesis Advisor: Linnea Avallone

Keith Paul Harrison, Ph.D., Physics
Dec 2003
“Groundwater processes in Martian valley network, outflow channel, and landslide formation”
Thesis Advisor: Robert Grimm

Shannon Pelkey, Ph.D., Astrophysical, Planetary, and Atmospheric Sciences
Dec 2003
“The Martian Surface Layer: Implications of thermal-infrared and other remote-sensing observations”
Thesis Advisor: Bruce Jakosky

L. Jeremy Richardson, Ph.D., Physics
May 2003
“Infrared Spectroscopy of the Transiting Extrasolar Planet HD 209458 b during Secondary Eclipse”
Thesis Advisor: Mihaly Horanyi

Graduate Students

Janice Armellini
Austin Barker
Amy Barr
Erika Barth
Todd Bradley
Shawn Brooks
Matthew Burger
Ed Burin Des Roziers
Phillip Chamberlin
Tim Chanthawanich
Steve Chappell
Peter Colarco
Zane Crawford
Christopher Cully
Sean Davis
Matthew Dean
Nathan Farr

Anselm Fernandez
Tiffany Finley
William French
Brandi Gamblin
Jennifer Gannon
Yu-Ning Ge
Tyler Goudie
Alexa Halford
Anna G. Hallar
Keith Harrison
Jennifer Heldmann
Gregory Holsclaw
Vaughn Hoxie
Christian Jeppeson
Stephen Johnstone
Grailing Jones
Lars Kalnajs

Olga Kalashnikova
Chris Kelso
Byoungsoo Kim
Corinne Krauss
Nancy Kungsakawin
Lin Li
Lindsey Link
Matthew Paul Lippis
Tim Lloyd
Kevin McGouldrick
Lansing Madry
Eric Mahr
David Main
Rebecca Matichuk
Colin Mitchell
Nate Murphy
Shannon Pelkey

Manny Presicci
Than Putzig
L. Jeremy Richardson
Josh Rigler
Eric Schleicher
Teresa Segura
Sara Sheffler
Ritchard Shidemantle
Cynthia Shaw Singleton
Hanna Sizemore
Andrew Steffl
Cody Vaudrin
Jeffrey Walker
John Weiss
Kaj Williams
Undergraduate Students

Alicia Allen   William French
Art Arsenault  Jeff Graw
Daniel J. Aschom Elizabeth Grogan
Jerry M. Brown  Jenny Guo
Nicholas Bunch  Rachel Gury
Jeremy Carnahan Andrew Hahn
Matthew Chojnacki Steven Harris
Josh Christofferson Aaron Hayden
Brian Clarke  Gene Holland
Matthew Colgan  Andrew Jenkins
Adam Cox  Matthew Kanter
Zane Crawford  Ryan Keenan
Kimdao Dang  Matthew Kelly
Lindsay De Remer  Thomas Keohane
Nathan Doyle  Emily Kramer
Jason Durrie  Ervin Krauss
Loren Eason  Otto Krauss
Allison Ebbets  Katherine Kretke
Pete Elespuru  Nathan Kunz
Attila Elteto  David Lawry
Brian Evans  Holly Lewis
Paul Feather  Matthew Lippis
Kurt Lorhammer
Michael Lupton
Sharon Lutz
Brian Madge
Kevin McBryde
Charles Malespin
Patrick Meagher
Jaeson Myers
Michael Neeland
John Neice
Rong Ngo
Trang Nguyen
Jonathan Nikkel
Kostas Pagratis
Jill Parisi
Brian Payne
Ann Pham
Michael Phan
William Pisano
Radu Popescu
Erica Raine
Nichole Ramos
Danica Reno
Brian Roberts
Kristin Roebuck
Matthew Route
Joshua Rubin
Laura Shaner
Mike Simpson
Phillip Siu
Jarod Smilkstein
Patrick Smith
Jordan Spatz
Steven Sutton
Linda Te
Jane Thompson
Katie Thompson
Mark Trafton
Thu Yen Tran
Karim Turk
Challon Winer
Marcus Wojtkowiak

Faculty Research Interests

Linnea Avallone
Experimental and theoretical studies of tropospheric and stratospheric chemistry, particularly of halogens and related species. Analyzing measurements of chemical species to understand dynamical processes in the stratosphere and troposphere. Development of instrumentation for autonomous in situ measurements of trace species related to understanding the lifetimes of anthropogenic pollutants.
avallone@miranda.colorado.edu (303) 492-5913

Frances Bagenal
Magnetic fields and plasma environments of solar system objects—mainly Jupiter and the Sun, but more recently, other planets, comets and asteroids.
bagenal@colorado.edu (303) 492-2598

Daniel N. Baker
Research in space instrument design and calibration, space physics data analysis, and magnetospheric modeling. Study of plasma physical and energetic particle phenomena in the magnetospheres of Jupiter and Mercury, along with the plasma sheet and magnetopause boundary regions of the Earth’s magnetosphere. Analysis of large data sets from spacecraft; involvement in missions to Earth’s deep magnetotail and comets; the study of solar wind-magnetospheric energy coupling; theoretical modeling of magnetotail instabilities. Study of magnetosphere-atmosphere coupling; applying space plasma physics to study of astrophysical systems. Research to understand space weather and effects on human technology. Teaching of space physics and public policy, as well as public outreach to space technology community and general public.
daniel.baker@lasp.colorado.edu (303) 492-4509
Charles A. Barth
Planetary ultraviolet spectroscopy; observation and theory of nitric oxide in the Earth’s upper atmosphere; research on planetary atmospheres. charles.barth@lasp.colorado.edu (303) 492-7502

Joshua E. Colwell
Origin and evolution of planetary rings, observational and theoretical studies of planetary rings, comets, and satellites including Earth’s moon. Impact processes on asteroids, satellites, and ring particles. Dynamics of dust in ring-satellite systems. Dusty plasma dynamics. Thermal models of airless bodies. josh.colwell@lasp.colorado.edu (303) 492-6805

Scot Elkington
Space physics theory and modeling, primarily understanding energetic particle dynamics in the inner magnetosphere in the context of radial diffusion and adiabatic transport processes within the radiation belts. Also working on models of plasma sheet access of energetic particles to the inner magnetosphere through convection/substorm injection, development of physical space weather radiation belt models, and magnetohydrodynamic/particle simulations. elkingto@lasp.colorado.edu (303) 735-0810

Erica Ellingson
The study of the evolution of galaxies, galaxy clusters, and quasars. Investigation of dark matter in distant galaxy clusters, the evolution of the galaxies in these clusters, and the properties of the intra-cluster gas. Observations with ground-based telescopes and use of several orbiting space observatories, extensive computer analysis and modeling. erica.ellingson@lasp.colorado.edu (303) 492-6610

Francis G. Eparvier
Research interests include the aeronomy of the upper atmosphere, the effects of solar irradiance and particle flux variability on the upper atmosphere, and the sources of that solar variability. Approaches include rocket and satellite measurements of the solar outputs and of the atmosphere, and data analysis and theoretical modeling. Currently Co-Investigator on the Thermosphere- Ionosphere-Mesosphere Energetics and Dynamics (TIMED) satellite Solar EUV Experiment (SEE).

eparvier@colorado.edu, (303) 492-4546, http://stripe.colorado.edu/~eparvier

Larry W. Esposito
Observational and theoretical studies of planetary atmospheres and rings; chemistry and dynamics of the Venus clouds; waves in Saturn’s rings; numerical methods for radiation transfer. espo@lasp.colorado.edu (303) 492-7325

Jerald Harder
Measurement and interpretation of solar spectral irradiance; Development of space-borne prism spectrometers. jerry.harder@lasp.colorado.edu (303) 492-1891

Mihaly Horanyi
Dusty space and laboratory plasmas. Electrodynamic processes and their role in the origin and evolution of the solar system. Comets, planetary rings, plasma surface interactions at moons and asteroids. Aerosol charging, in situ and remote observations of dust. mihaly.horanyi@lasp.colorado.edu (303) 492-6903

Bruce M. Jakosky
Teaching and research activities focus on understanding the nature of planetary surfaces and atmospheres and the possibility for the existence of life in the universe. Specific activities include teaching undergraduate and graduate courses, training graduate students, research and grant activity pertaining to planetary science and exobiology, leading the campus effort in astrobiology, exploring the nature of the interactions between science and society, and outreach to the public. bruce.jakosky@argyre.colorado.edu (303) 492-8004

Greg Kopp

George M. Lawrence
Physical chemistry, laboratory spectroscopy, experiment design and analysis, signal conditioning, vacuum technology, IR detectors, UV detectors, imaging detectors, microchannel plates. george.lawrence@lasp.colorado.edu (303) 492-5389
**Steven W. Lee**

Development of computer techniques for analysis and correlative study of multiple remote-sensing data sets; Digital image processing techniques; Physics of atmosphere/surface interactions; Mechanisms and rates of eolian sediment transport; Effects of topography on regional atmospheric circulation; Educational outreach: incorporating planetary science into K-12 curricula.

steve.lee@lasp.colorado.edu (303) 492-5348

**Xinlin Li**

Space physics, data analysis and modeling. Especially interested in understanding the dynamics of relativistic electrons in the magnetosphere: the source, loss, and transportation of these MeV electrons; also interested in charged particle injections into inner magnetosphere during magnetic storms and substorms, and magnetosphere-atmosphere coupling due to energetic particle precipitations.

lix@kotron.colorado.edu (303) 492-3514

**William E. McClintock**

Observational Astrophysics - Ultraviolet observations of the outer atmospheres of cool stars and the very local (d<20pc) interstellar medium. Ultraviolet Observations of Planetary Atmospheres. Development of state-of-the-art instrumentation for high resolution spectroscopy for the 900-2500/ wavelength range.

bill.mcclintock@lasp.colorado.edu (303) 492-8407

**Michael Mellon**

The history of water on Mars, the martian permafrost, surface-atmosphere interactions and the martian climate. Periglacial geology and geophysics on Earth and Mars. Use of ice-related geomorphic features as an indicating of the distribution of subsurface ice. Antarctic analogs to martian geomorphology. Laboratory research in transport processes in frozen soils, including gas diffusion and solute migration and the effects of water vapor, ice, and adsorbate on transport physics. Remote sensing and thermophysical properties of planetary regoliths, with specific emphasis on martian surface material. Planetary surface temperature behavior and geothermal heat flow.

mellon@argyre.colorado.edu (303) 492-1711

**Michael Mills**

Research has focused on stratospheric sulfate aerosol. The current research tool is a 2D microphysical model of the troposphere, stratosphere, and mesosphere. A primary goal has been to assess the sources of the nonvolcanic stratospheric sulfate layer, and understand anthropogenic contributions. Because of the role of aerosol in stratospheric chemistry and radiative balance, this knowledge of its sources is critical to understanding global change. Recent efforts have attempted to understand discrepancies between observed and calculated aerosol mass at the top of the layer. Other work has examined the causes of observed particle nucleation in polar winter, the implications for aerosol of recently measured photolysis rates for H2SO4 and SO3, and volcanic aerosol as a potential source for polar mesospheric clouds.

mills@colorado.edu (303) 492-7767

**Keiji Ohtsuki**

Theoretical studies of planet formation; origin and dynamical evolution of ring-satellite systems.

ohtsuki@lasp.colorado.edu (303) 492-0260

**Cora E. Randall**

Primary interests include atmospheric chemistry and dynamics, mainly of the stratosphere, and secondarily of the mesosphere and troposphere. Work is experimental in nature, relying on data from remote sensing satellites. The emphasis is on ozone, NO2, and aerosol data from the Polar Ozone and Aerosol Measurement (POAM) instrument as well as from the Stratosphere Aerosol and Gas Experiment (SAGE). Measurements from instruments on the Upper Atmosphere Research Satellite (UARS) and the Solar Mesosphere Explorer (SME) are also used. Other interests include the spectroscopy of comets and laboratory polarization measurements.

cora.randall@lasp.colorado.edu (303) 492-8208

**Gary J. Rottman**

Accurately measure the solar spectral irradiance (Principal Investigator on sounding rockets, UARS, EOS, SORCE, TSIM, and GLORY and Co-Investigator on SME, TIMED, and SDO). Special emphasis is given to solar variability on all time scales and to comparisons of the solar irradiance with the output of other late type stars. Past work has concentrated on the ultraviolet ($\lambda<300$) irradiance, but emphasis has not extended to the visible
and near-infrared. Application of ultraviolet spectroscopy and the development of new instrumentation for remote sensing.
gary.rottman@lasp.colorado.edu (303) 492-8324

David W. Rusch
The general fields of spectroscopy and aeronomy, emphasizing the measurements of minor constituents and aerosols in planetary atmospheres such as nitric oxide and ozone and the physical and chemical phenomena which determine their densities and temporal variations. Research in the atmospheric sciences including stratospheric, mesospheric, and thermospheric data analysis and modeling. Application of the principles of molecular and atomic spectroscopy in the measurement of ultraviolet, visible, and near-infrared emission and absorption features to obtain understanding of atmospheric phenomena. Current research involves the determination of atmospheric processes affecting ozone and the reevaluation of ozone trends from long-term satellite measurements.
rusch@sertan.colorado.edu (303) 492-8627
http://lasp.colorado.edu/~rusch/dwr.html

Nicholas M. Schneider
The physics of planetary magnetospheres, particularly the interactions between planetary plasmas and the satellites of the outer planets. Extensive groundbased observations of the Jupiter/Io system, especially imaging and spectroscopy of the Io atmosphere and plasma torus. Program has been expanded to include Hubble Space Telescope observations. Designing and building of a spacecraft to study the Jupiter/Io system.
nick.schneider@lasp.colorado.edu (303) 492-7672
http://ganesh.colorado.edu/nick

Martin Snow
Primary research interests include ultraviolet spectroscopy of stars and the sun and the interaction of comets with the solar wind. The SOLSTICE instruments on UARS and SORCE provide a wealth of information about solar activity in the 115-300 nm range on a variety of timescales, ranging from minutes (solar flares) to decades (solar cycle). Understanding the variation in the solar output will lead to understanding its influence on the Earth. The interaction of comets with the solar wind is best studied using wide-field photography. Both amateur and professional astronomers contribute to this effort, and one research activity has been to help coordinate the interaction of the two groups.
marty.snow@lasp.colorado.edu 303-735-2143

A. Ian F. Stewart
The investigation by ultraviolet emissions of the aeronomy of planetary and satellite atmospheres, cometary comae, and Io's plasma torus.
stewart@viralf.colorado.edu (303) 492-4630

Glen R. Stewart
Origin and evolution of the solar system, with an emphasis on modeling the solid-body accretion of the terrestrial planets and the solid cores of the giant planets. Accretion of the Moon after a giant impact on the Earth. Modeling of satellite wakes and spiral density waves in planetary rings. Nonlinear dynamics of the three-body problem as applied to problems in solar system dynamics.
glen.stewart@lasp.colorado.edu (303) 492-3737

Gary E. Thomas
Research concerning the middle atmosphere of Earth, in particular the mesosphere (50-100 km). Of interest are noctilucent clouds which occur in the high-latitude summertime mesopause region, around 83 km. These clouds were observed for five years by a CU LASP ultraviolet experiment onboard the LASP SME satellite, and more recently by instruments onboard the POAM II and UARS (Upper Atmosphere Research Satellite) spacecraft. In the last decade, interest involves global change in this region, possibly caused by anthropogenic emissions and by climate changes in the troposphere. Critical parameters studied are solar UV flux, water vapor, temperature and ozone which are being monitored by instruments onboard the UARS.
gary.thomas@lasp.colorado.edu (303) 492-7022
http://lasp.colorado.edu/noctilucent_clouds

O. Brian Toon
Theoretical studies of stratospheric aerosols; investigations of volcanic aerosols and studies of polar stratospheric clouds; theoretical studies of tropospheric clouds, aerosols and radiative transfer; experimental investigations of stratospheric and tropospheric phenomena; theoretical investigations of planetary atmospheres.
btoon@lasp.colorado.edu (303) 492-1534

Robert Weigel
Dynamics and physics of solar wind/magnetosphere/ionosphere coupling. Modeling of high-

Robert.Weigel@lasp.colorado.edu (303-492-2159)

**Thomas N. Woods**

Observational studies of the solar ultraviolet (UV) radiation, its variability, and its interaction with Earth's atmosphere. Principal investigator of NASA suborbital program to study the solar irradiance and thermospheric airglow. Principal investigator of the Solar EUV Experiment (SEE) on the TIMED mission. Co-investigator of the Solar Stellar Irradiance Comparison (SOLSTICE) experiment currently making solar UV irradiance measurements on the Upper Atmosphere Research Satellite (UARS) and planned for the Earth Observing System (EOS) missions.

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**Courses Taught at the University of Colorado by LASP Faculty**

### Spring 2003

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Course Code(s)</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linnea Avallone</td>
<td>ATOC 6020</td>
<td>Seminar in Atmospheric and Oceanic Sciences</td>
</tr>
<tr>
<td>Frances Bagenal</td>
<td>ASTR 1110</td>
<td>Introductory Astronomy – Solar System</td>
</tr>
<tr>
<td>Daniel N. Baker</td>
<td>ASTR 4800</td>
<td>Space Science – Practice and Policy</td>
</tr>
<tr>
<td>Francis Eparvier</td>
<td>ASTR/ATOC 3720</td>
<td>Planets and Their Atmospheres</td>
</tr>
<tr>
<td>Larry Esposito</td>
<td>ASTR 1110</td>
<td>Introductory Astronomy</td>
</tr>
<tr>
<td>Mihaly Horanyi</td>
<td>PHYS 3310</td>
<td>Principles of electricity and Magnetism I</td>
</tr>
<tr>
<td>Mihaly Horanyi</td>
<td>PHYS 3320</td>
<td>Principles of electricity and Magnetism II</td>
</tr>
<tr>
<td>Robert Pappalardo</td>
<td>ASTR/GEOL 4830</td>
<td>Special Topics: Europa</td>
</tr>
</tbody>
</table>

### Fall 2003

<table>
<thead>
<tr>
<th>Instructor</th>
<th>Course Code(s)</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linnea Avallone</td>
<td>ATOC 6020</td>
<td>Seminar in Atmospheric and Oceanic Sciences</td>
</tr>
<tr>
<td>Linnea Avallone</td>
<td>ATOC 4800/5000</td>
<td>Critical Issues in Climate and Policy</td>
</tr>
<tr>
<td>Joshua Colwell</td>
<td>ASTR 1110</td>
<td>General Astronomy – Solar System</td>
</tr>
<tr>
<td>Larry Esposito</td>
<td>ASTR/GEOL 3750</td>
<td>Planets, Moons, and Rings</td>
</tr>
<tr>
<td>Bruce Jakosky</td>
<td>GEOL 3300/ASTR 3300</td>
<td>Extraterrestrial Life</td>
</tr>
<tr>
<td>Mihaly Horanyi</td>
<td>PHYS 3320</td>
<td>Principles of electricity and Magnetism II</td>
</tr>
<tr>
<td>Robert Pappalardo</td>
<td>ASTR/GEOL 5800</td>
<td>Planetary Surfaces and Interiors</td>
</tr>
</tbody>
</table>
FACULTY ACTIVITIES

AAU Space Science Working Group
  Esposito, Larry (Member)

Air Force Technical Applications Center (AFTAC) Satellite Review Panel
  Baker, Daniel (Chair)

American Association for the Advancement of Science (AAAS)
  Jakosky, Bruce (Convenor and Session Chair)
  Jakosky, Bruce (Member, Program on Dialogue on Science, Ethics, and Religion Advisory Committee)

American Geophysical Union
  Baker, Daniel (Member, Governing Council and Nominations Committee)

American Geophysical Union Fall Meeting
  Avallone, Linnea (Session Chair)
  Baker, Daniel (Convenor, Special Session)
  Elkington, Scot (Session Co-Chair)
  Mellon, Michael (Session Convenor)
  Rottman, Gary (Convenor, Special Session)

American Geophysical Union, Atmospheric Sciences Section
  Avallone, Linnea (Member Atmospheric Chemistry Technical Committee)

American Geophysical Union, Electronic Publishing
  Baker, Daniel (Chair, Electronic Publications Review Panel)

American Geophysical Union, Space Physics and Aeronomy Section
  Baker, Daniel (President)

Associate Editor – Journal of Geophysical Research (Atmospheres)
  Avallone, Linnea

Associate Editor – Journal of Space Weather
  Baker, Daniel
  Elkington, Scot (ISEC 2003 special session)

Associate Editor – Reviews of Geophysics
  Bagenal, Frances

BFA Library Committee
  Horanyi, Mihaly (Member)

Boulder Matrix Space Advisory Group
  Baker, Daniel (Chair)
  Himes, Caroline (Member)

COSPAR 34 Planetary Atmospheres
  Esposito, Larry (Main Scientific Organizer)

Calibration Conference (CALCON)
  Kopp, Greg (Session Chair)

Climate and Weather of the Sun-Earth System Working Group
  Eparvier, Francis (Member)

CLUSTER Science Working Team
  Baker, Daniel (Member)
College of Arts and Sciences
Avalone, Linnea (Member, Appeals Committee on Academic Rules and Policies)

Conference on Space Weather
Baker, Daniel (Member, Organizing Committee)

Denver Museum of Nature and Science
Colwell, Joshua (Scientific Consultant)
Horanyi, Mihaly (Scientific Consultant)
Pappalardo, Robert (Scientific Consultant to Planetarium show on Astrobiology)
Stewart, Glen (Scientific Consultant)

Dissertation/Thesis Committees
Bagenal, Frances
Baker, Daniel
Elkington, Scot
Esposito, Larry
Horanyi, Mihaly
Jakosky, Bruce
Mellon, Michael
Pappalardo, Robert

Editorial Board Member
Jakosky, Bruce (Geobiology, Astrobiology, Int. J. Astrobiology, Cambridge
University Press Astrobiology Book Series)

Education and Public Outreach
Bagenal, Frances (Various public talks about Galileo Mission to Jupiter and New Horizons mission to Pluto)
Baker, Daniel (Newspaper interviews and Television appearances; Public/Guest lecturer)
Colwell, Joshua (Visiting Researcher, Challenger Center for Space Science Education)
Jakosky, Bruce (Public/Guest lecturer)
Kopp, Greg (Invited monthly speaker; Northern Colorado Astronomical Society)
Pappalardo, Robert (NPR Program: Water – The Marvelous Molecule)
Randall, Cora (AIM Science team advisor; Boulder Valley School District)
Rottman, Gary (SORCE launch activity; Public/Guest lecturer)
Snow, Martin (Boulder Valley School District; IBM Science-o-rama)
Woods, Thomas (Boulder Valley School District)

ESPRIT Space Weather Conference
Baker, Daniel (Member, Organizing Committee)

Geological Sciences Subcommittee for Self-Study
Jakosky, Bruce (Member)

Geophysical Research Letters
Pappalardo, Robert (Associate Editor)

Geospace Environment Modeling (GEM) Working Group
Elkington, Scot (Co-Chair)

Independent Study/Research Study Groups
Esposito, Larry (Supervisor)

International Assoc. for Geomagnetism and Aeronomy
Baker, Daniel (U.S. National Delegate)
Baker, Daniel (Bureau Member)
Baker, Daniel (Chair, IGY+ 50 Task Force)

International Heliospheric Year Planning Group
Baker, Daniel (Chair)
International Probe Workshop
   Esposito, Larry (Member, Scientific Organizing Committee)

International Union of Geodesy and Geophysics
   Baker, Daniel (Member, U.S. National Committee)
   Baker, Daniel (Member, IGY+50 Advisory Committee)
   Baker, Daniel (U.S. Representative)

Journal of Atmospheric and Solar Terrestrial Physics
   Baker, Daniel (Regional Editor)

Jupiter Icy Moon Orbiter
   Pappalardo, Robert (Member, NASA Science Definition Team)

LASP Business Committee
   Baker, Daniel (Chair)
   Davis, Randal
   Himes, Caroline
   McGrath, Michael
   Rottman, Gary
   Stewart, Ian

LASP Computer Systems Advisory Committee
   Colwell, Josh
   Evans, Phil
   Himes, Caroline
   Klemp, Margi
   Lankton, Mark
   Mills, Mike
   Weiss, John
   Woody, Mia
   Woods, Tom (chair)

LASP Curriculum Review Committee
   Avallone, Linnea (Co-Chair)
   Eparvier, Francis
   Li, Xinlin
   Rusch, David (Co-Chair)

LASP Education and Public Outreach Committee
   Avallone, Linnea (Member)
   CoBabe-Ammann, Emily
   Eparvier, Francis (Chair)
   Lee, Steve
   Randall, Cora
   Stewart, Glen

LASP Executive Committee
   Baker, Daniel (Chair)
   CoBabe-Ammann, Emily
   Davis, Randal
   Esposito, Larry
   Himes, Caroline
   Horanyi, Mihaly
   Jakosky, Bruce
   Li, Xinlin
   McClintock, William
   McGrath, Michael
   Randall, Cora
   Rottman, Gary
   Stewart, Ian
Woods, Thomas

**LASP Director’s Reappointment Committee**
- Ergun, Robert
- Horanyi, Mihaly
- Randall, Cora

**LASP Library Committee**
- Eparvier, Francis (Chair)
- Horanyi, Mihaly
- Knapp, Barry
- Reed, Heather
- Simmons, Karen

**LASP Merit Evaluation Committee**
- Esposito, Larry
- Himes, Caroline
- McGrath, Michael
- Rottman, Gary
- Stewart, Ian
- Toon, O. Brian

**Manuscript Reviewer**
- Colwell, Joshua (Addison-Wesley Longman Textbooks, Planetary and Space Science)
- Esposito, Larry (J. Geophys. Res., Icarus)
- Pappalardo, Robert (Icarus, Nature)
- Randall, Cora (JGR, GRL, J. Atmos. Sci., Annales Geophysicae)

**Mars Ice Sample Study Team**
- Mellon, Michael (Member)

**Mars Odyssey Project Science Group**
- Jakosky, Bruce (Member)

**Masters or Ph.D. Qualifying Examination Committee**
- Avallone, Linnea (Member)

**MESSENGER/Mercury Orbiter Science Working Team**
- Baker, Daniel

**NAS Space Studies Board Atmosphere-Ionosphere-Magnetosphere Coupling**
- Baker, Daniel (Panel Member)

**NAS Space Studies Board Decadal Survey for Solar and Space Physics**
- Bagenal, Frances (Member)
- Baker, Daniel (Member)

**NAS Committee on Planetary and Lunar Exploration (COMPLEX)**
- Pappalardo, Robert (Member, Space Studies Board)

**NASA Astrobiology Institute Insight Course in Planetary Science**
- Jakosky, Bruce (Organizer and Lecturer)

**NASA Living With a Star MOWG**
- Baker, Daniel (Chair)
NASA Living With a Star Workshop Scientific Organizing Committee
   Eparvier, Francis (Chair)
   Woods, Thomas

NASA Magnetospheric Multiscale Mission
   Baker, Daniel (Member, Study Team)

NASA Mars Exploration Program Analysis Group
   Jakosky, Bruce (Chair)

NASA Mars Exploration Review Team
   Jakosky, Bruce (Member)

NASA Mars Landing Site Steering Group
   Jakosky, Bruce (Member)

NASA/JPL Mars Science Laboratory Project Science Integration Group
   Jakosky, Bruce

NASA Nuclear Systems Initiative Science Definition Team
   Esposito, Larry (Member)

NASA Solar System Exploration Subcommittee
   Jakosky, Bruce (Member)
   Pappalardo, Robert (Member)

NASA Sun-Earth Connections Roadmap Committee
   Baker, Daniel (Advisor)

National Oceanic and Atmospheric Administration (NOAA)
   Baker, Daniel (Member, Strategic Planning Group)

National Polar Orbiting Operational Satellite System (NPOESS)
   Kopp, Greg (Member, Operational Algorithm Team)

National Science Foundation Advisory Panel on Faculty Development in Space Sciences
   Baker, Daniel (Member)

NCAR Upper Troposphere/Lower stratosphere Initiative Progressive Science Campaign Committee
   Avallone, Linnea (Member)

New York Hall of Science, Extraterrestrial Life Exhibit Advisory Panel
   Jakosky, Bruce (Member)

   Baker, Daniel (Panel Member)

Optical Society of America
   Kopp, Greg (Director at Large, Rocky Mountain Section)

PAOS Admissions Committee
   Randall, Cora (Member)

PAOS Comprehensive Exam Committee
   Avallone, Linnea (Member)
   Randall, Cora (Member)

PAOS Curriculum Committee
   Avallone, Linnea (Member)
Physics Department Comps Committee
   Horanyi, Mihaly (Chair)

Physics Department Undergraduate Committee
   Horanyi, Mihaly

Polar Science Working Team
   Baker, Daniel (Member)

Principal Dissertation/Thesis Advisor for Graduate Student(s)
   Avallone, Linnea
   Bagenal, Frances
   Baker, Daniel
   Esposito, Larry
   Horanyi, Mihaly
   Jakosky, Bruce
   Pappalardo, Robert
   Randall, Cora
   Woods, Thomas

Principal Thesis Advisor for Undergraduate Student(s)
   Pappalardo, Robert

Probe Science and Technology Workshop
   Esposito, Larry (Local Organizer)

Program on Women in Astronomy II
   Bagenal, Frances (Program Chair)

Proposal Reviewer
   Avallone, Linnea (NSF/Division of Geosciences; NASA)
   Elkington, Scot (NASA and National Science Foundation)
   Horanyi, Mihaly (NSF, DOE, and NASA)
   Jakosky, Bruce (NASA, Mars Data Analysis, Mars Fundamental Research,
                 Cosmochemistry, and MUCERPI Programs)
   Kopp, Greg (NASA Living With a Star Targeted Research Technology (TRT) Program)
   Mellon, Michael (NASA Mars data Analysis, Planetary Geology and Geophysics,
                 Mars Fundamental Research)
   Pappalardo, Robert (NASA Planetary Geology/Geophysics Program and NASA
                 Exobiology Program)
   Randall, Cora (NIES Japan, Australian Antarctic Science Program)

SAMPEX Science Working Team
   Daniel Baker (Member)

University of Colorado Faculty Advisory Committee on IT
   Bagenal, Frances (Member)

University of Colorado Aerospace Engineering Department
   Baker, Daniel (Member, External Advisory Board)

University of Colorado Center for Limb Atmospheric Sounding
   Baker, Daniel (Deputy Director)

University of Colorado Chancellor’s Federal Relations Advisory Committee
   Baker, Daniel (Member)

University of Colorado Graduate School/Institute Directors Group
   Baker, Daniel (Member)
University without Walls Committee
Baker, Daniel (Member, Vision 2010)

USRA Astronomy and Space Physics Council
Baker, Daniel (Member)

USRA Council of Institutes
Baker, Daniel (Representative)

USRA Lunar and Planetary Institute Science Council
Jakosky, Bruce (Member)

FACULTY HONORS/AWARDS

AcademicKeys Who’s Who in Sciences Higher Education (WWSHE)
Baker, Daniel

Alan Berman Research Publication Award (Naval Research Laboratory)
Randall, Cora

American Geophysical Union Congressional Fellowship
Avalone, Linnea (Finalist)

Fellow of the American Physical Society
Horanyi, Mihaly

Mindlin Foundation Lecturer
Baker, Daniel

NASA Group Achievement
Avalone, Linnea (Cirrus Regional Study of Tropical Anvils and Cirrus Layers)
Jakosky, Bruce (Mars Global Surveyor Project Science Group)

Residence Life Academic Teaching Award
Joshua Colwell (Recipient)

University of Colorado Outstanding Graduate Advising Award
Avalone, Linnea (Nominee)

University of Colorado President’s Faculty Excellence Award for Advancing Teaching and Learning through Technology
Bagenal, Frances (Nominee)

Colloquia and Informal Talks
Spring 2003

Daniel Baker, CU / LASP. SAMPEX - 10 Years of Sun-Earth Connections Science with Energetic Particle Measurements
John Bally, CU/APS. Star and Planet Formation
Robert Blankenship, University of Washington. The transition from anoxygenic to oxygenic photosynthesis and how it changed the Earth

Kevin Boyce, Harvard University. How to make a leaf? 400 million years of repeated answers to the same evolutionary question
Paul Brekke, SOHO Project Scientist. SOLARMAX
Donald Brownlee, University of Washington. Stardust-A Mission Returning Comet Samples to Earth
Roger Buick, University of Washington. A Subsurface Biota in the Archean?
Francis Eparvier, CU/LASP. TIMED SEE Results
John Grant, National Air & Space Museum. Selecting Landing Sites for the 2003 Mars Exploration Rovers

Gannet Haller, CU/LASP. Total Water Measurement during CRYSTAL-FACE in Key West, Florida
David Hochberg & Jose Maria Perez Gomez, Centro de Astrobiologia. Multicellular and Multicolonial Bacterial Patterns: Implications for Astrobiology
Brian Hynek, Washington University. Mars: New Insights into an Exciting Past

George Lawrence, CU/LASP. What I have learned in 32.5 years at LASP
Ruth Ley, CU/EPOB. The Amazon Basin of the Mud World: Dizzying Microbial Diversity at Guerrero Negro's Salt Mats
Victoria Meadows, JPL. Characterizing Extrasolar Terrestrial Planets: The Virtual Planetary Laboratory
Michelle Minitti, Arizona State University. Assessing the effect of impact shock on water in amphibole: Implications for the Martian meteorites

Keiji Ohtsuki, CU/LASP. Formation of Kuiper-belt binaries
Than Putzig, CU/LASP. Thermal Inertia of the Martian South Polar Region
Tom Quinn, University of Washington. The formation of giant planets
Alex Pavlov, CU/LASP. Atmospheric methane and oxygen in Archaean and Proterozoic: Constraints from sulfur

Cora E. Randall, CU/LASP. The Anomalous 2002 Antarctic Ozone Hole
Gary Rottman, CU/LASP. The Solar Radiation and Climate Experiment
Henry Scott, CIW. Chemical stratification and hydrocarbon stability in large icy satellites
Anurag Sharma, Carnegie Institute. Experimental window into high pressure Geobiology
Everett Shock, Arizona State University. Are Hot Springs Extreme Environments?

Stan Solomon, HAO/NCAR. A Brief History of TIMED: Mais ou sont les neiges d'antan?
Michelle Stempel, CU/LASP. Europa’s Lineaments and Surface Stresses
Jim Tiedje, Michigan State University. Microbial and Genomic insights into microbial life in permafrost

Allan Treiman, Lunar and Planetary Institute. Martian Gullies: Recent water, CO₂, or What?
Harry Warren, Naval Research Laboratory. An Emission Measure Approach to Modeling Solar EUV Irradiance Variability

Erik Wilkinson, CU/CASA. Aberration-corrected Holographic Gratings: Why and How
Sam Yee, Applied Physics Laboratory, Johns Hopkins University. Stellar Occultation Techniques for Remote Sensing of Earth’s Atmosphere

Fall 2003

Jill Banfield, University of California at Berkeley. An Fe, S-sustained subsurface biosphere: insights through linking geochemistry and genomics

Charles Barth, CU/LASP. Seasonal Variation of Auroral Electron Precipitation
Clark Chapman, SouthWest Research Institute. What is Known about the ‘Late Heavy Bombardment’ and How it Might Constrain Astrobiology?
Brian Fraser, University of Newcastle New South Wales. The Propagation of Electromagnetic Ion Cyclotron Waves in the Middle Magnetosphere

Jennifer Heldmann, NASA/Ames. An Investigation of Recent Water on Mars
Kai-Uwe Hinrichs, Woods Hole Oceanic Institute. Organic biosignatures for microbial processes in the terrestrial marine subsurface

Ken Hon, University of Hawaii at Hilo. Lava Flows and Lava Tubes: What They Are and How They Form
Julie Huber, University of Washington. Expanding the sub-seafloor biosphere to ridge flanks and beyond

Bruce Jakosky, CU/LASP&GEOL. Mars Atmosphere Evolution and Planetary Habitability
Mike Mellon, CU/LASP. Seeking Icy Permafrost on Mars

Adrian Melott, University of Kansas. Did a Gamma-Ray Burst Initiate the Ordovician Extinction?

Alex Pavlov, CU/LASP. Passing Through a Giant Molecular Cloud Snowball Glaciations Produced by Interstellar Dust

Anatoli K. Pavlov, Director of the Russian Astrobiology Center. Age of Liquid Water on Mars and Martian Bugs on Earth?! Where to Look for Martian Life?

Jamison Smith, CU/LASP. Stratospheric Humidity, Deep Convection, and Isotopic Fraction

Robert S. Weigel, CU/LASP. Space Weather Modeling and Prediction

Nick Woolf, University of Arizona. Terrestrial Planet Finder and the timing of the Great Oxygen Event. Was the delay caused by Biology or Geology?

Edward Young, University of California, Los Angeles. Oxygen Isotope Heterogeneity in the Early Solar System: A Signature of Water

Chris Zeller and Diana Mann. Presentation of American Institute for Aeronautics and Astronautics and a Report From the World Space Congress

Publications


Hibbitts, C., R. T. Pappalardo, G. Hansen, and T. McCord, Carbon dioxide on Ganymede, J.
Mitchell, C.J., M. Horányi, and J.E. Howard, Epi-cyclic Description of Dust Grain Orbits about
Thomas, P. C., P. Giersch, D. Bandfield, R. Sullivan, D. S. Miller, E. Alvarz del Castillo, B.


Papers Presented at Scientific Meetings


Colwell, J.E., and S. Sture, Experimental studies of low-velocity microgravity impacts into regolith, 34th Lunar and Planetary Science Conference, Houston, TX, March 2003.


Horányi, M., Dusty Plasma Effects at Jupiter and Saturn, EGS, Nice, France, April, 2003.


Jakosky, B.M., Mars atmospheric evolution and planetary habitability—Synergy between space science and astrobiology, NASA/Ames Research Center, May 2003.


Li, X., Current status of the theory and modeling of radiation belt electrons in the magnetosphere,
Li, X., Enhanced physical understanding based on prediction of relativistic electrons using solar wind as input, EGS-EGU-AGU, Nice, France, 6-11 April, 2003.
Li, X., Predictability of the magnetosphere, Space Environment Center, NOAA, Boulder, CO, 6 November, 2003.
Mitchell, C., J.E., Colwell, and M. Horanyi, Tenuous Ring of Captured Dust at Saturn; Division of Planetary Sciences, 2003.
Mitchell, C., J., J.E., Colwell, and M. Horanyi, Tenuous Ring of Captured Dust at Saturn; Fall AGU meeting, San Francisco, CA, December 2003.
Monk, S., D.N. Baker, P.W. Daly, T.A. Fritz, R. Friedel, and J.B. Blake, Multispacecraft obser-


Randall, C.E., Intercomparison of SAGE III, POAM III and ozonesonde data, SOLVE-2 science team meeting, October 2003.


Randall, C.E., Solar occultation contributions to Aura validation, Aura science team meeting, September 2003.

Randall, C.E., Solar occultation data intercomparison and validation of ILAS-II, ILAS-II science team meeting, July 2003.


Rottman, Gary, SORCE – the Solar Radiation and Climate Experiment, GSFC Scientific Colloquium, Greenbelt, MD, October 2003.


Snow, M., Stellar Observations with SOLSTICE, CALCON 2003, Logan, UT 2003


Su, Y.-J., Electron acceleration by Alfvén waves, a contributed discussion in the M-I coupling section at the GEM meeting, June, 2003.

Su, Y.-J., Jupiter-Io Interaction, contributed discussion in the M-I coupling section at the GEM meeting, June, 2003.


**SPONSORED PROGRAMS**

Andersson, Laila – Investigation of H+ and O+ outflows from the Earth’s ionosphere

Andersson, Laila – Micro physics of the downward current region of the aurora

Avallone, Linnea – PECASE: In situ measurements of halogen oxides in the troposphere and enhancement of graduate education in atmospheric sciences

Avallone, Linnea – Improvements to In Situ measurements of ice water content using tunable diode laser spectroscopy

Avallone, Linnea – IGERT: Graduate training in atmospheric observations

Avallone, Linnea – Measurements of total water and carbon dioxide during Crystal-FACE

Bagenal, Frances – Analysis of MGS magnetometer data and comparisons with models of Mars’ magnetic field and solar wind interaction

Bagenal, Frances – Galileo: Interdisciplinary Study of the Io Plasma Torus

Bagenal, Frances – New Horizons Pluto Mission
Bagenal, Frances – Magnetosphere-Ionosphere coupling at Earth and Jupiter: Similarities and differences
Bagenal, Frances – Mass and Energy Flow Through the Io Plasma Torus
Bagenal, Frances – Pluto-Kuiper belt mission
Bagenal, Frances – Solar wind interaction with Comet Borrelly
Baker, Daniel – Center for Integrated Space weather Modeling (CISM)
Baker, Daniel – Mercury MESSENGER
Baker, Daniel – Radiation Belt Specification and forecasting with data assimilation
Baker, Daniel – NASA Goddard CEPPAD
Baker, Daniel – Space Weather Forecasting: Predicting radiation belt electrons using adaptive ARMA filters and data assimilation
Baker, Daniel – Solar Cycle Dynamics of Solar Magnetospheric and Heliospheric Particles and Long-Term Atmospheric Coupling SAMPEX – Data Analysis
Baker, Daniel – CLUSTER data analysis program
Baker, Daniel – NASA HIRDLS Science
Baker, Daniel – NASA HIRDLS Program Management
CoBabe-Ammann – Space Weather – A new planetarium experience
Colwell, Joshua – Collisional and electrostatic transport of dust in the regolith of EROS
Colwell, Joshua – Development support, testing and documentation of SOA
Colwell, Joshua – Experimental studies of low velocity impacts into regolith
Colwell, Joshua – Dynamics of charged dust near surfaces in space
Davis, Randal – Mission operations of the NASA Quikscat satellite
Delamere, Peter – In-space propulsion technologies cycle 2
Delamere, Peter – Pluto’s kinetic interaction with the solar wind
Delamere, Peter – SKID-X: The interaction between parallel electric fields and the transport of energy and momentum in space plasmas
Elkington, Scott – GEM: Transport and trapping of energetic plasma sheet electrons in the outer zone radiation belts
Elkington, Scott – GEM: A parametric study of geomagnetic storms during magnetic cloud intervals using global MHD simulations
Ergun, Robert – Development of light-weight wire booms and sensors for electric field measurements on space plasma missions
Ergun, Robert – FAST satellite operations and data analysis
Ergun, Robert – Lobe cell convection and polar cap precipitation
Ergun, Robert – Microphysics of the downward current region of the aurora
Ergun, Robert – Time history of events and their macroscopic interactions during substorms (THEMIS)
Ergun, Robert – Origins of nonlinear wave structures and particle heating in current driven plasmas
Ergun, Robert – GEM: Self-consistent characterization of parallel electric fields in the lower magnetosphere
Ergun, Robert – Influence of double layers and electron holes on observed phenomena in the auroral downward current region
Ergun, Robert – Modeling of parallel electric fields in the aurora
Eriksson, Stefan – Flank Magnetopause Reconnection, the Sash, and Lobe Convection
Esposito, Larry – Surface-Atmosphere Geochemistry Explorer (SAGE) – New Frontiers: Concept study
Esposito, Larry – Cassini mission operations and data Analysis
Esposito, Larry – UV imaging spectrograph for Cassini
Horanyi, Mihaly – Dusty plasmas in planetary magnetospheres: Earth, Jupiter, and Saturn
Horanyi, Mihaly – Mesospheric aerosol particle spectrometer
Horanyi, Mihaly – Cassini CDA Investigations
Horanyi, Mihaly – Cosmic dust experiment instrument (CDE) for the AIM (NASA/SMEX) mission
Horanyi, Mihaly – Student Dust Counter Experiment (SDC) for the New Horizons Pluto Mission
Horanyi, Mihaly – Electrostatic Discharges on Mars
Horanyi, Mihaly – HST Observations of Jupiter’s ring system
Jakosky, Bruce – Remote sensing and geochemistry of planetary surfaces
Jakosky, Bruce – Thermal imaging system
Jakosky, Bruce – Mars Global Surveyor Interdisciplinary Scientist
Jakosky, Bruce – Physical properties of potential Mars landing sites
Jakosky, Bruce – Mars Global Surveyor Data Analysis Project
Jakosky, Bruce – University of Colorado Center for Astrobiology
Jakosky, Bruce – Mars Odyssey THEMIS Experiment
Jakosky, Bruce – Mars Odyssey Project Science Group
Jakosky, Bruce – Thermal inertia of the Mer landing sites
Lee, Steven W. – Ozone, condensates and dust in the martian atmosphere
Li, Xinlin – Quantitative forecast and specification of radiation belt electrons
Li, Xinlin – Dynamics of radiation belt electrons associated with solar wind variations
Li, Xinlin – Radial transport and precipitation loss of outer belt electrons
Li, Xinlin – Detailed study of the magnetic storms selected for GEM inner magnetosphere and storms campaign
Li, Xinlin – Solar wind fluctuations and their consequences on the magnetosphere
Li, Xinlin – Source of radiation belt electrons
McClintock, William – Atmospheric and surface composition spectrometer (ASCS) and Co-Investigator support for the MESSENGER mission
McCollom, Thomas – Experimental study of Geochemical processing of prebiotic organic compounds on the early Earth, Mars and meteorites
McCollom, Thomas – A gas chromatograph/mass spectrometer system to study prebiotic organic processes
McCollom, Thomas – Experimental investigation of organic synthesis in submarine hydrothermal systems
McGrath, Michael – Mechanics of granular materials microgravity experiment
McGrath, Michael – Student Dust Counter Experiment (SDC) for the New Horizons Pluto Mission
Mellon, Michael – Shallow grown ice on Mars
Mellon, Michael – PHOENIX Mars Scout Mission, Science Co-Investigator
Mellon, Michael – Distribution of near-surface ground ice on Mars
Mellon, Michael – Geophysics of Martian periglacial processes
Mellon, Michael – SHARAD: Mars subsurface sounding radar characterization experiments, theory and mission support
Mellon, Michael – High-Resolution Thermal Inertia of Mars
Mellon, Michael – HIRISE: High-Resolution imaging science experiment
Mellon, Michael – Geophysics of Martian periglacial processes
Ohtsuki, Keiji – Dynamical evolution of ring-satellite systems
Ohtsuki, Keiji – Formation and dynamical evolution of planets
Ohtsuki, Keiji – Origin and evolution of irregular satellites
Pappalardo, Robert – Analysis of structural evolution of grooved terrain on Ganymede
Pappalardo, Robert – Improved calibration and rectification of Galileo NIMS data from the four Galilean satellites and selected scientific analysis
Pappalardo, Robert – Characteristics and consequences of faulting on Ganymede and Europa
Pappalardo, Robert – Astrobiological and geological implications of convective transport in icy outer planet satellites
Pappalardo, Robert – Astrobiological and geological implications of diapiric transport with Europa and Ganymede
Pappalardo, Robert – Causes and consequences of faulting on Europa and other icy satellites
Peterson, William – TIMAS operations and data analysis
Peterson, William – Intergovernmental Personnel Agreement: Discipline in the Sun-Earth Connection Division
Pryor, Wayne – Jovian Lyman-Alpha aeronomy
Randall, Cora – Ozone loss inferred from satellite data and a 3D CTM
Randall, Cora – SAGE III science and validation focused on the UTLS
Randall, Cora – Derivation of ozone photochemical loss by combining satellite data and a 3-dimensional chemical transport model
Randall, Cora – Occultation data intercomparison and evaluation
Randall, Cora – Validation of POAM III data
Randall, Cora – Assimilation of ozone data sets
Robertson, Scott – Mechanical behavior and charging properties of granular materials in space environments
Rottman, Gary – UARS SOLSTICE continued operations
Rottman, Gary – Special study for the Solar Irradiance Instruments
Rottman, Gary – Solar irradiance gap filter (SIGF) special study for the Solar Irradiance Instruments
Rottman, Gary – SORCE/EOS
Rusch, David – Investigation of the effect of solar variability and particle ionization on the Earth’s middle atmosphere
Rusch, David – Stellar occultation measurements: A new application of spatial heterodyne spectroscopy for determining atmospheric composition
Rusch, David – Aeronomy of Ice in the Mesosphere (AIM)
Schneider, Nicholas – From Io’s atmosphere to the plasma torus
Schneider, Nicholas – Satellite atmosphere and Io Torus observations
Stewart, Ian – UVS/EUV participation in Galileo Europa mission
Stewart, Glen – Dynamics of planetesimals and planetary accretion
Stewart, Glen – Physics of structures in self-gravitating, collisional rings
Stewart, Glen – Dynamical models of solar system formation and evolution
Stewart, Glen – Evolution of protoplanetary disks near the snowline

Su, Yi-Juin – Cusp dynamics – particle acceleration by Alfvén waves
Thomas, Gary – Polar mesospheric cloud properties determined from SBUV and SBUV/2 measurements
Thomas, Gary – Solar-induced variations in polar mesospheric clouds
Toon, Owen B. – Aerosol changer, aerosol robotic network/micro pulse lidar-net site and numerical modeling
Toon, Owen B. – Investigations of clouds and aerosols in the stratosphere and upper troposphere
Toon, Owen B. – Influence of nucleation mechanisms on the radioactive properties of deep convective clouds and subvisible cirrus in Crystal-FACE
Toon, Owen B. – Particles in reducing atmospheres: Applications to early Earth and Titan
Toon, Owen B. – Investigations of desert dust and smoke in the North Atlantic in support of the TOMS instrument
Toon, Owen B. – Modeling the environmental effects of large impacts on Mars
Woods, Thomas – TIMED Solar EUV Experiment (SEE) – Phase E
Woods, Thomas – SDO EVE Variability Experiment (EVE) – Phase A/B