Laboratory for **A**tmospheric and **S**pace **P**hysics

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**

A Message from the Director

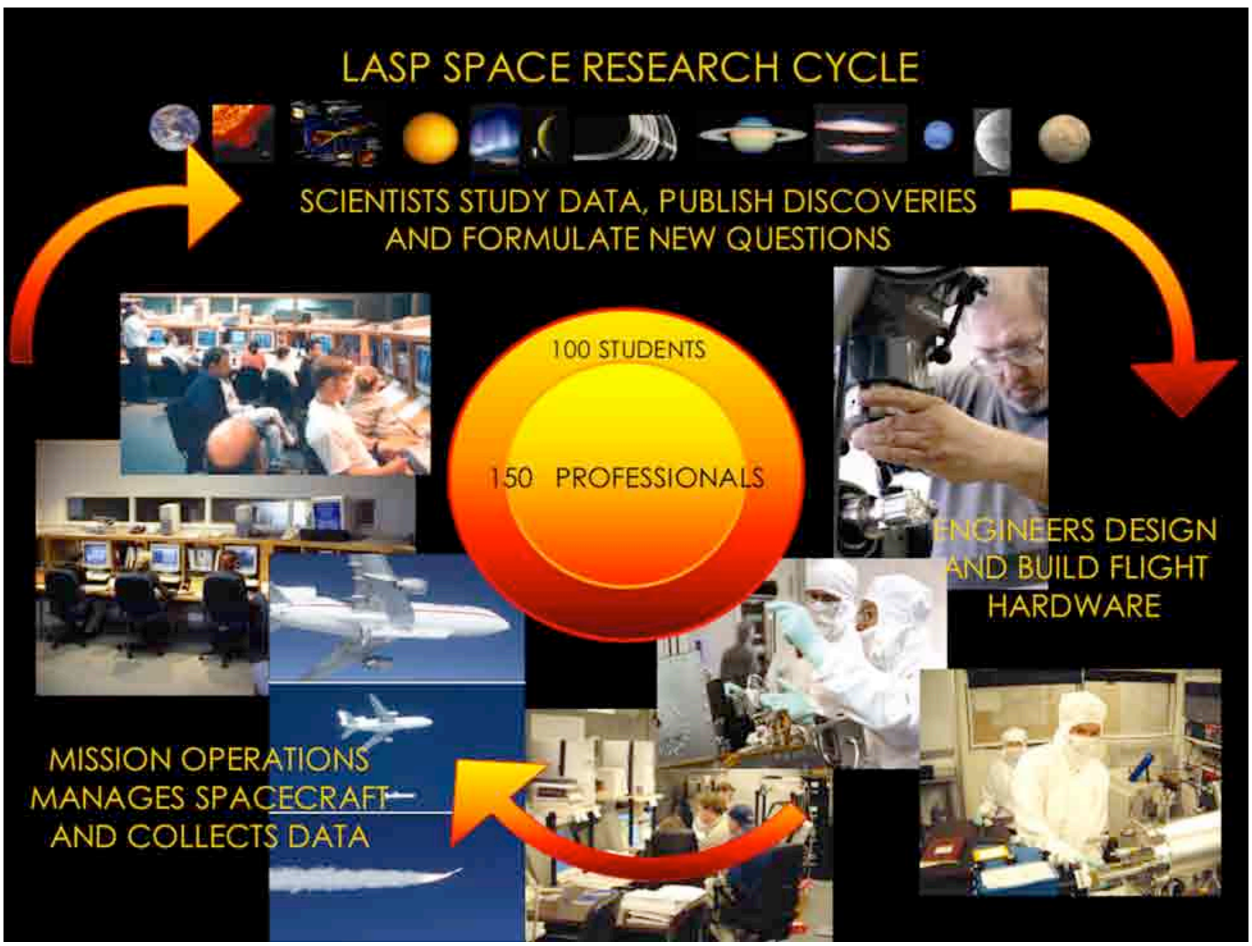
The present time is a period of tremendous growth and expansion for LASP. New scientific programs have been added and many new staff members have joined. We can point with pride to the successful designing, building, and testing of new spacecraft instruments (as reported in these pages) and we can also 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

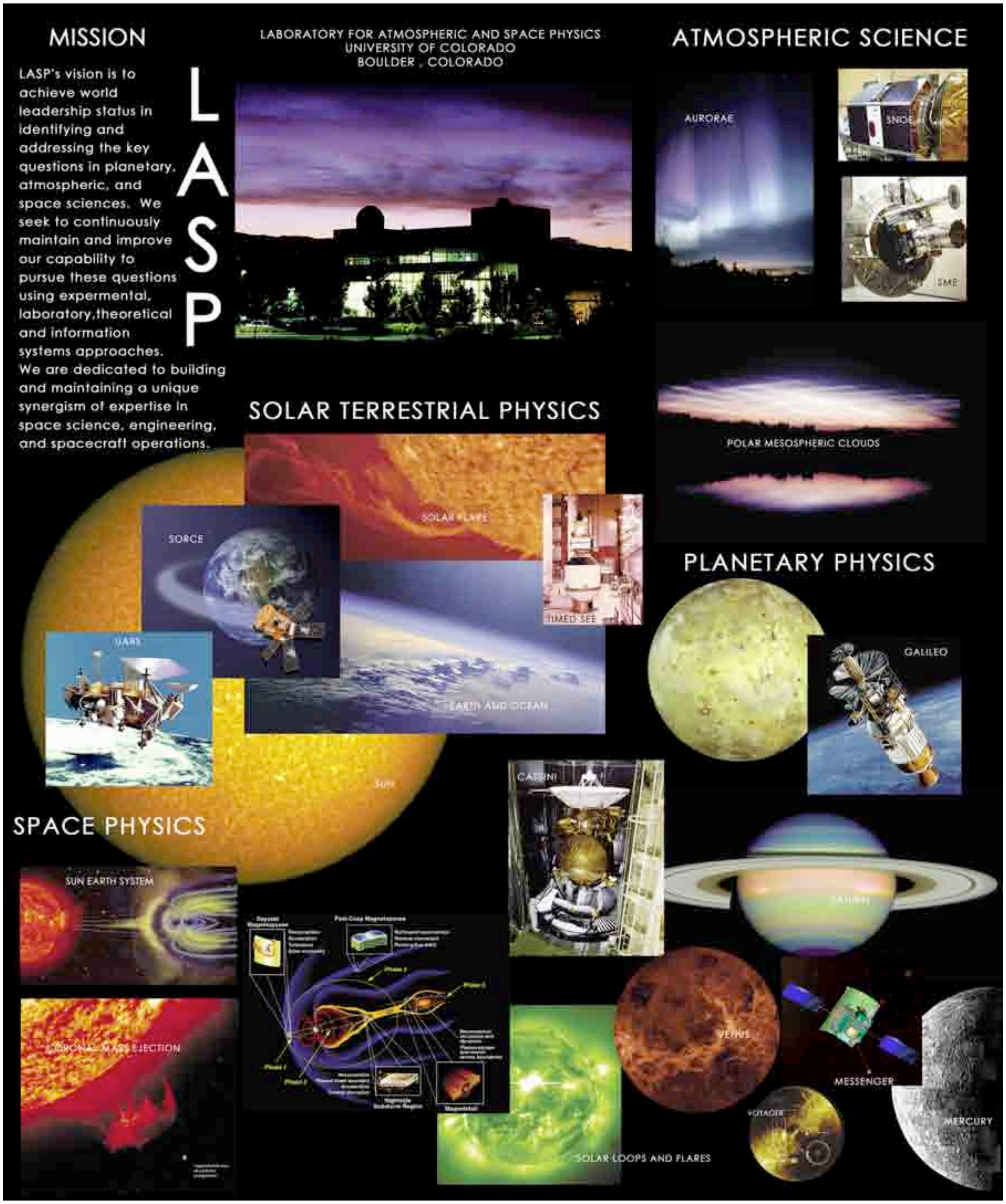


Research Support: 2003 Fiscal Year

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

Source of Funding	Total Grant Dollars
Federal Agencies:	
Department of Energy	$2,708
DOD - Department of the Navy	$114,000
National Aeronautics and Space Administration	$17,342,876
National Science Foundation	$875,687
Non-Federal Agencies:	
Arizona State University	$302,296
Ball Aerospace Systems Division	$519,978
Boston University	$598,426
Computational Physics, Inc.	$109,830
Federal Data Corporation	$12,000
Hampton University	$9,364,142
Jet Propulsion Laboratory	$1,083,480
Johns Hopkins University	$1,352,053
Northrop Grumman	$150,000
Science Systems and Applications, Inc.	$10,313
Southwest Research Institute	$663,900
Space Telescope Science Institute	$28,600
University Corporation for Atmospheric Research	$13,306
University of California at Berkeley	$648,643
University of Maryland	$130,833
Totals:	$33,343,158

Science Spotlights



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.

The **XPS** instrument measures the very energetic EUV and soft x-ray flux, where the solar variability exceeds a factor or two. Its precision and relative accuracy requirements are therefore on the order of ±10%. It measures broadband spectral irradiance from 1 to 34 nm, and is designed similar to the XPS on the TIMED (Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics) satellite. The XPS extends the solar XUV irradiance measurements with improved accuracy, spectral range, and temporal coverage. The solar XUV radiation is emitted from the hot, highly variable corona on the Sun, and these high-energy photons are a primary energy source for heating and ionizing Earth's upper atmosphere.

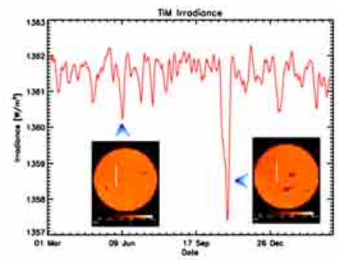
Mission and Science Operations

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.

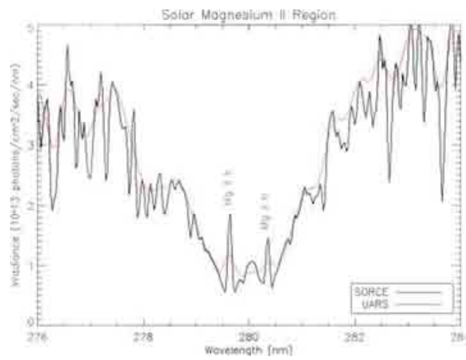
The science operations from the MOC include experiment planning, data processing and analysis, validation, and distribution of the finished data product. By early March 2003, all instrument doors were open and science operations had begun. The first validated science data were received approximately 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/m^2 or $W/m^2/nm$). 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

Science Results



The **TIM** tracks total solar irradiance with a few part per million sensitivity as solar activity, such as the shown sunspots, affect the Sun's radiative output.



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.

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 nonstop 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.

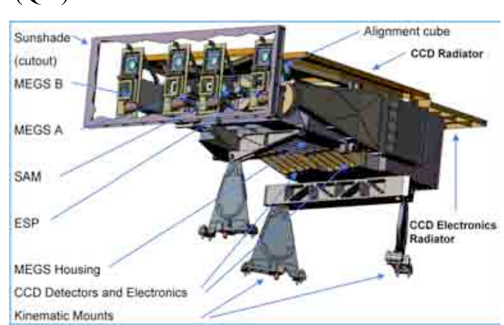
The LASP lobby has 4 new instrument photos, and a large 10' wide by 7.5' tall SORCE display outside the Mission Operations Center. The portable display features the spacecraft, instruments, and a science overview. LASP also created a SORCE poster and bendable cube, and continues to use the hands-on SORCE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

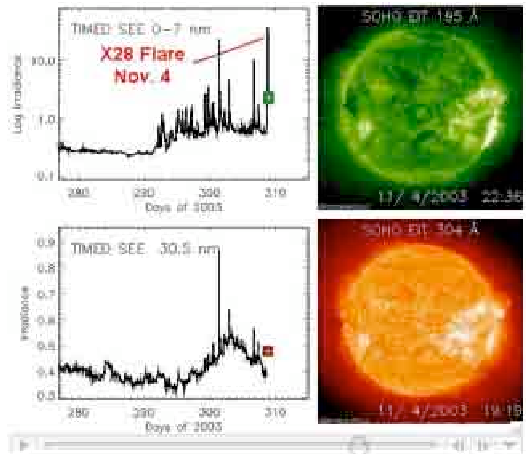


TIMED Solar EUV Experiment (SEE)

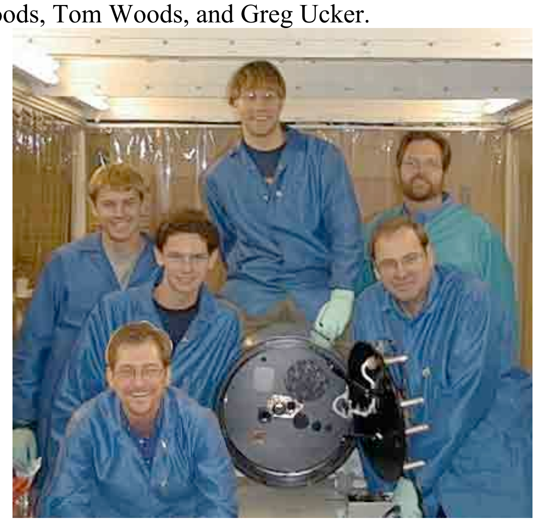
The Solar EUV Experiment (SEE), built at LASP, is one of four scientific instruments on the NASA Thermosphere-Ionosphere-Mesosphere-Energetics-Dynamics (TIMED) spacecraft. The TIMED spacecraft was launched (NASA 36.205) on December 7, 2001, and the SEE instrument has made daily measurements of the solar 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:

http://lasp.colorado.edu/see/TIMED_SEE_Oct2003_web.mov



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.



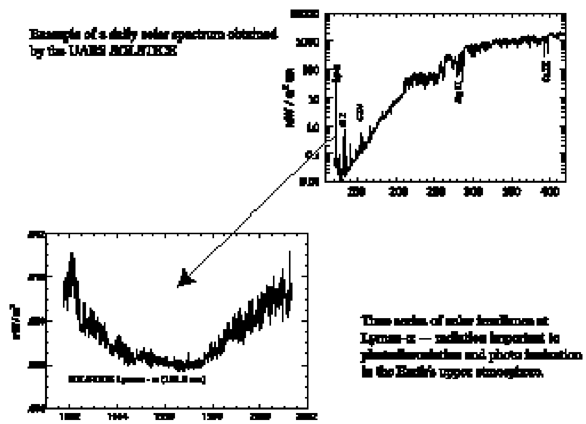
LASP scientists analyzing the TIMED SEE data are Tom Woods (PI), Frank Eparvier, Gary Rottman, and Don Woodraska. SEE flight operations staff includes Don Woodraska, Phil Chamberlin, Tom Woods, Karen Turk, Frank Eparvier, and Matt Kelly.

THE UARS Solar Stellar Irradiance Comparison Experiment – SOLSTICE

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.

ATMOSPHERIC SCIENCE

Student Nitric Oxide Explorer (SNOE)

At 9:34AM 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 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, subisokinetic 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 Midlatitude 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 conti-

nental 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 atmosphere, 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.

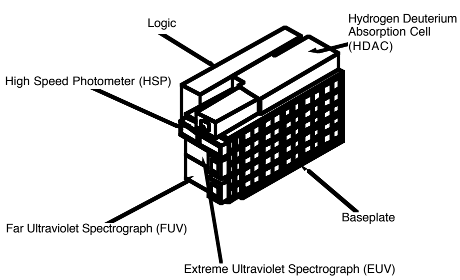
In January 2003 MGM was launched aboard Columbia for STS-107, its third space flight mission. A total of 10 experiments were performed in microgravity during the flight. Downlink data provided both real-time views of the experiments and an invaluable record for later analysis. Uplink commanding allowed 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.

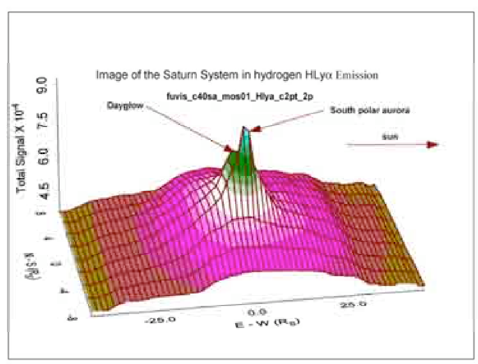


Figure: Cassini UVIS Observation of the Saturn System in emission of the atomic hydrogen resonance line (HLya)

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 (R_S), and the extreme extent in latitude evidently significantly beyond 8 R_s 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 R_s 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 R_s in the east-west direction, and 2. R_s (interpolated) in the north-south direction.

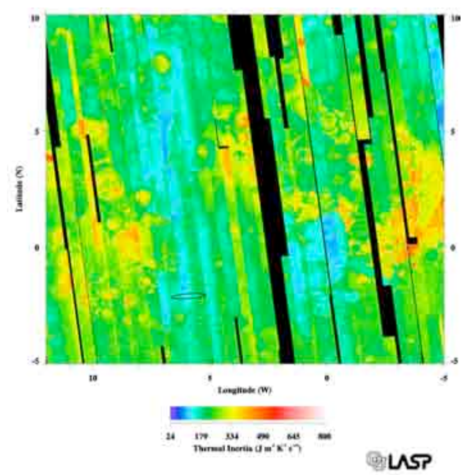
The LASP UVIS Science team includes Principal Investigator Larry Esposito, Co-Investigators George Lawrence, Bill McClintock, Charles Barth, Joshua Colwell, and Ian Stewart. Alain Jouchoux is the Operations Team Leader, assisted by Michelle Kelley and Darren Osborne. For further information, please visit 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.



Meridiani THEMIS Band 9 Derived TI

Student Dust Counter (SDC)

Dust disks around other stars (like Beta Pictoris or Epsilon Eridani) display complex structures that are thought to be the tell tale 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 polyvinylidine-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.

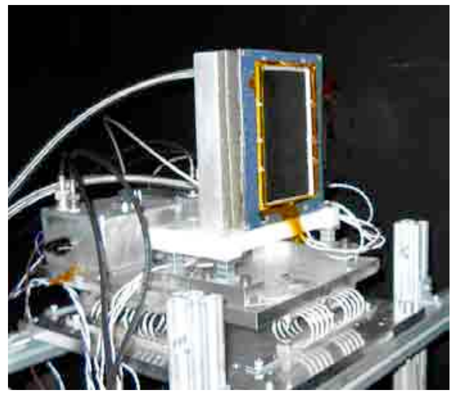


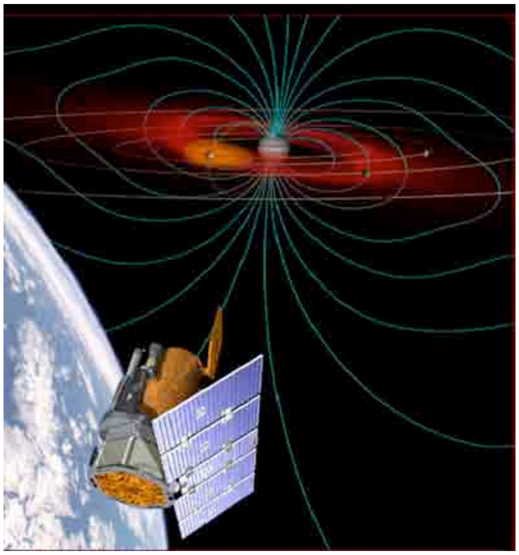
Figure: The sensitivity of a single PVDF sensor was tested as function of its temperature at the Heidelberg, Germany dust accelerator facility. Shown here is one of the SDC detectors with its temperature controls inside the target chamber.

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.

For further information, please see: **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 ≥45° 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 ≤45° 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, 28.5° 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*.

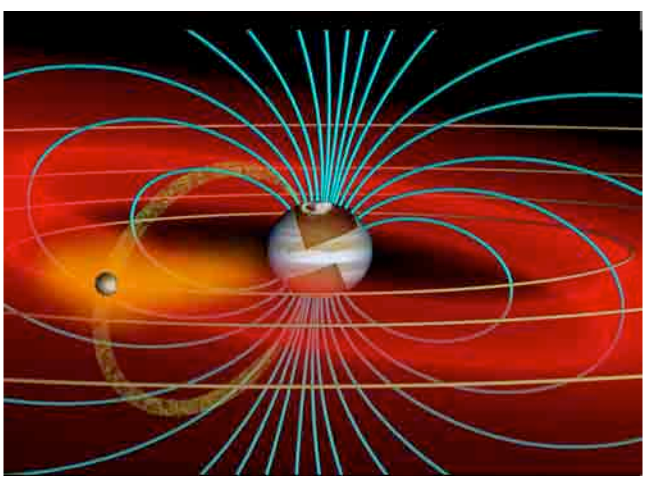
The JMEX Team	
University of Colorado	Project Management (Tom Spam, PM) Extreme UltraViolet Spectrograph (EUVS) UltraViolet Imager Instrument Package (UVIIP) Payload Integration and Test Mission Operations Center EUVS Data Center Education & Public Outreach
Goddard SFC	UltraViolet Telescope (UVT)
Ball Aerospace & Technologies Corp.	RS300 Spacecraft Bus Observatory Assembly, Integration and Test
Boston University	UVI Data Center
Siegmund Scientific	Photon-counting UV Detectors
Aerospace Corp.	Mission Assurance

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:

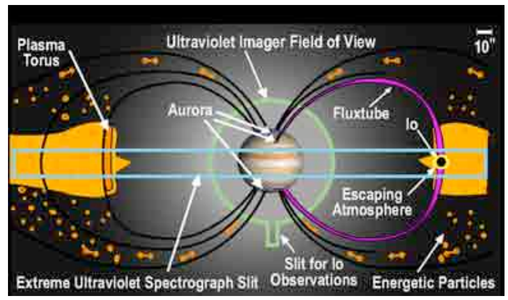
- Which processes in Jupiter's magnetosphere are influenced by the solar wind (as at Earth), and which processes are controlled by Io?
- Does plasma production depend on Io's volcanic activity, or is it controlled by Io's magnetospheric interaction?
- How does the magnetosphere respond to internal plasma 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 ≤0.2" optical image quality.
- An image Motion Sensor enables innovative jitter mitigation through post-processing, providing ≤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.

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

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**

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**.

Figure: Earth is the only planet in our solar system known to have life, but Mars and Europa, shown here with the Earth, appear to meet all of the environmental criteria necessary to be able to support life. Future exploration will determine whether life exists there or not.

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 multi-satellite 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.

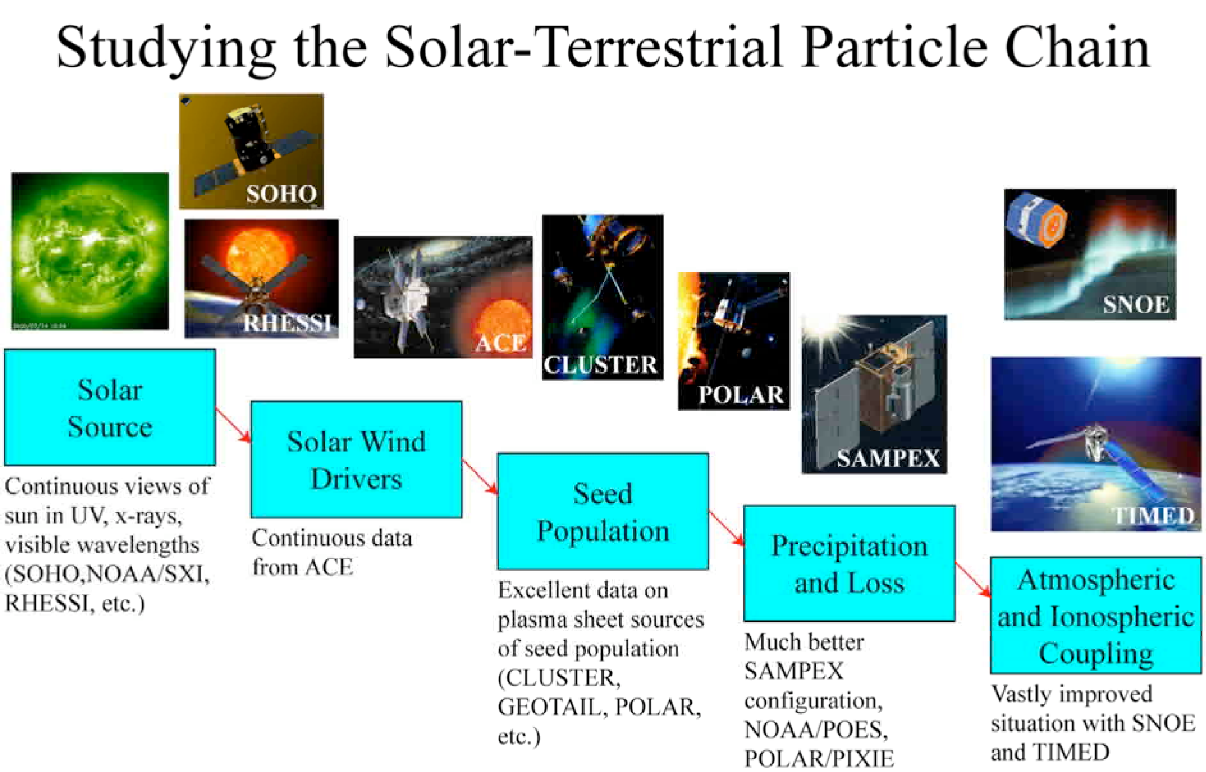
For further information, please see: **http://sprg.ssl.berkeley.edu/themis/**

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.

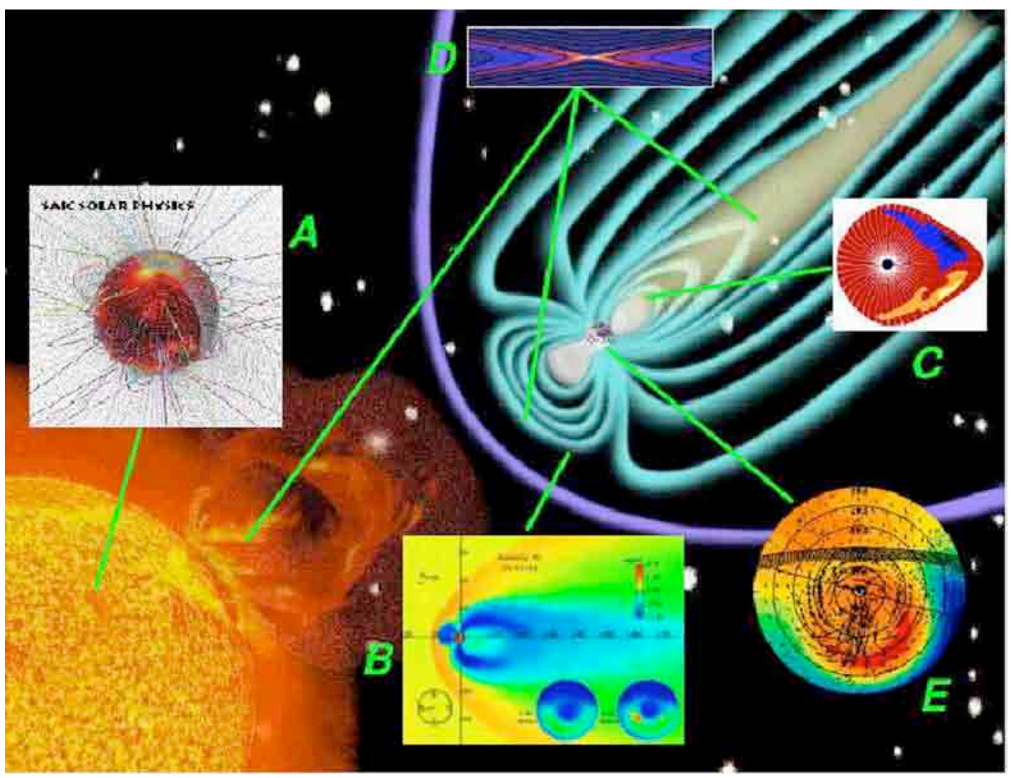
LASP scientists Daniel N. Baker, Xinlin Li, and Josh Rigler are working on magnetospheric data from SAMPEX. New results have been obtained by comparing relatively low-energy (E>25keV) electrons measured by SAMPEX with SNOE measurements of nitric oxide in Earth's upper and middle atmosphere. This collaborative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



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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Daniel N. Baker
Director

Laila Anderssen
Linnea M. Avallone
Frances Bagenal
Charles A. Barth (Ret.)
David Brain
Emily CoBabe-Ammann
Joshua E. Colwell
Peter Delamere
Scot Elkington
Erica Ellingson
William Emery
Francis G. Eparvier
Robert Ergun
Stefan Eriksson
Larry W. Esposito
Janet C. Green
Robert E. Grimm
Jerald W. Harder
Lynn Harvey
Noel Hinners
Mihály Horányi
Brian Hynek
Bruce M. Jakosky
Greg Kopp
George M. Lawrence (Ret.)
Steven W. Lee
Xinlin Li
William E. McClintock
Tom McCollom
Sara Martinez-Alonzo
Michael Mellon
Michael Mills
Steve Mojzsis
Keiji Ohtsuki
Robert T. Pappalardo
Alexander Pavlov
Shannon Pelkey
William Peterson
Cora E. Randall
Gary J. Rottman
David W. Rusch
Theodore Sarris
Nicholas M. Schneider
Chao Shen
Jamison Smith
Byron Smiley
Martin Snow
A. Ian F. Stewart
Glen R. Stewart
Yi-Jin Su
Gary E. Thomas
Henry B. Throop
O. Brian Toon
Robert Weigel
Thomas N. Woods

Visiting Scholars

Dr. Joseph Ajello, Jet Propulsion Laboratory
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. Dean Posnell, NASA Goddard Space Flight Center
Dr. Chao Shen, Chinese Academy of Sciences, Beijing
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Michael T. Callan
Zachary Castleman
Zhangzhao Chen
Wesley Cole
Lillian Connelly
David Crotser
John A. Daspit
Randal L. Davis
Kip W. Denhalter
Lindsay DeRemer
John Donnelly
Sharon Dooley
Michael Dorey
Virginia Drake
Kathryn F. Eason
Peter Elespuru
Steve Ericksen
Phillip L. Evans
Jack Faber
Stacy Varnes Farrar
Tawnya Ferbiak
John Fontenla
David Gathright
Michael Gehmeyr
Vanessa George
Judith (Dede) Gleason
Ken Greist
Bonnie Kae Grover
Roger Gunderson
Scott Gurst
Christine Hathaway
Karl Heuerman
Meredith Higbie
Caroline Himes
Rose A. Hoag
Timothy Holden
Bonnie W. Hotard
Vaughn Hoxie
Andrew Hunt
James Johnson
Alain J. Jouchoux
David E. Judd
Ryan Keenan
Michelle Kelley
Marjorie K. Klemp
Barry Knapp
Richard Kohnert
Jay Kominek
Bret Lamprecht
Mark R. Lankton
Sally Lasater
Thomas Lowensohn
Debra McCabe
Sherry McGlochlin
Michael McGrath
James Mack
Melanie McKinney
Karen M. MacMeekin
Ken Mankoff
Jack Marshall
Willie Mein
Russell Meinzer
Nathaniel Miller
Steve P. Monk
Aref Nammari
Toan Nguyen
Sara Ohrtman
Chris Pankratz
Nicole Ramos
Thomas Reese
Randy Reukauf
Pat Ringrose
Timothy Ruske
Marissa Rusinek
Cynthia Russell
Jill Ryan
Sean Ryan
Tim Schofield
Patti Sicken
Karen Simmons
Thomas Sparn
Stephen Steg
Kenneth Stevens
Gail Tate
Susan Tower
Janet Tracy
Matt Triplett
Gregory Ucker
Douglas Vincent
Jeffrey Weber
Paul Weidmann
James Westfall
Neil White
Ann Williams
Dave Wilson
Ann Windnagel
Heather R. Withnell
Peter Withnell
Donald Woodraska
Mia Woody
Ed Wullschleger
Alan Yehle
Jason Young
Steve Zdawczynski
Torsten Zorn

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
Art Arsenault
Daniel J. Aschom
Jerry M. Brown
Nicholas Bunch
Jeremy Carnahan
Matthew Chojnacki
Josh Christofferson
Brian Clarke
Matthew Colgan
Adam Cox
Zane Crawford
Kimdao Dang
Lindsay De Remer
Nathan Doyle
Jason Durrie
Loren Eason
Allison Ebbets
Pete Elespuru
Attila Elteto
Brian Evans
Paul Feather
William French
Jeff Graw
Elizabeth Grogan
Jenny Guo
Rachel Guryn
Andrew Hahn
Steven Harris
Aaron Hayden
Gene Holland
Andrew Jenkins
Matthew Kanter
Ryan Keenan
Matthew Kelly
Thomas Keohane
Emily Kramer
Ervin Krauss
Otto Krauss
Katherine Kretke
Nathan Kunz
David Lawry
Holly Lewis
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
Karin 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

Development and characterization of the SORCE, Glory, and NPOESS Total Irradiance Monitors for solar irradiance measurements. Solar physics. Electro-optical instrumentation and electrical substitution radiometry.
Greg.Kopp@lasp.colorado.edu, 303-735-0934

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-

energy electrons in the magnetosphere. Models of the dynamics of ground magnetic fields and their time derivatives based on the solar wind state. Prediction of temporal fluctuations in ground magnetic fields with high-dimensional nonlinear regression methods (neural networks). Low-dimensional physics-based models of geomagnetic storms and substorms. Characterization of the relaxation of ionospheric currents after passage of solar wind disturbance. Studies of short-time scale geomagnetic fluctuations and characterization of their probability distribution functions. Statistical and empirical model development for space weather prediction. Decision Theory applied to space weather forecasting problems.
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.
tom.woods@lasp.colorado.edu (303) 492-4224

Courses Taught at the University of Colorado by LASP Faculty

Spring 2003

Linnea Avallone	ATOC 6020	Seminar in Atmospheric and Oceanic Sciences
Frances Bagenal	ASTR 1110	Introductory Astronomy – Solar System
Daniel N. Baker	ASTR 4800	Space Science – Practice and Policy
Francis Eparvier	ASTR/ATOC 3720	Planets and Their Atmospheres
Larry Esposito	ASTR 1110	Introductory Astronomy
Mihaly Horanyi	PHYS 3310	Principles of electricity and Magnetism I
Mihaly Horanyi	PHYS 3320	Principles of electricity and Magnetism II
Robert Pappalardo	ASTR/GEOL 4830	Special Topics: Europa

Fall 2003

Linnea Avallone	ATOC 6020	Seminar in Atmospheric and Oceanic Sciences
Linnea Avallone	ATOC 4800/5000	Critical Issues in Climate and Policy
Joshua Colwell	ASTR 1110	General Astronomy – Solar System
Larry Esposito	ASTR/GEOL 3750	Planets, Moons, and Rings
Bruce Jakosky	GEOL 3300/ASTR 3300	Extraterrestrial Life
Mihaly Horanyi	PHYS 3320	Principles of electricity and Magnetism II
Robert Pappalardo	ASTR/GEOL 5800	Planetary Surfaces and Interiors

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
Avallone, 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

Avallone, Linnea (Geophys. Res. Lett., J. Geophys. Res.)
Colwell, Joshua (Addison-Wesley Longman Textbooks, Planetary and Space Science)
Elkington, Scot (J. Geophys. Res., Geophys. Res. Lett., Adv. Space Science)
Esposito, Larry (J. Geophys. Res., Icarus)
Horanyi, Mihaly (JGR-Space, Physics of Plasmas, Nature, Icarus)
Jakosky, Bruce (Nature, Geophys. Res. Lett., J. Geophys. Res., Icarus)
Mellon, Michael (J. Geophys. Res. – Planets, Geophys. Res. Lett., Nature, Icarus)
Pappalardo, Robert (Icarus, Nature)
Randall, Cora (JGR, GRL, J. Atmos. Sci., Annales Geophysicae)
Woods, Thomas (J. Geophys. Res., Astron. & Astrophys.)

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)

Nonlinear Modeling in Geophysics (2003)
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
Avallone, Linnea (Finalist)

Fellow of the American Physical Society
Horanyi, Mihaly

Mindlin Foundation Lecturer
Baker, Daniel

NASA Group Achievement
Avallone, 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
Avallone, 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, CO_2, 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?

Glenn Sellar, Univ. Central Florida. Advances in the Design of Imaging Spectrometers for Remote Sensing and Planetary Science

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

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