LASP SPACE
Laboratory for Atmospheric and Space Physics
University of Colorado **Boulder**
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SPACE PHYSICS ISSUE

Features: **MMS update • LASP provides IMAP instrument & SOC • Parker Solar Probe launches • Mission operations revolution**

Letter from the director

Dan Baker

Explorer 1 made the first great discovery of the Space Age 60 years ago. James Van Allen and his team showed that Earth is shrouded in belts of magnetically confined, high-energy charged particles. This revelation fascinated humanity and led to research that continues today. LASP is involved in the NASA Van Allen Probes mission, which is rewriting textbooks about Earth's radiation belts. LASP designs, builds, and operates sensors to measure Earth's space environment and extends this work far beyond Earth's domain.

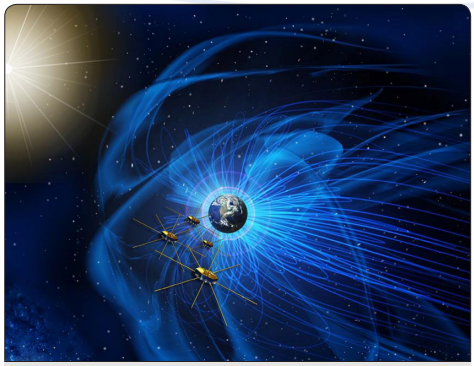
Understanding the space environment is a fascinating science enterprise and is of great practical importance. Virtually all communications, weather, and other remote sensing spacecraft on which society depends fly in near-Earth space. These "eyes in the sky" operate in a hostile radiation environment. The understanding we develop at LASP advances science and makes space safer for human and robotic explorers alike.

The theme of this issue is as timely as today's headlines: Space beckons and understanding it must go hand-in-hand with exploration. LASP is leading the way.

IN FOCUS

MMS update

Magnetic reconnection is a universal process in space. At Earth, the interplanetary magnetic field embedded in the solar wind can be opposite to the Earth's magnetic field. In this case, the two fields will merge, or reconnect, in an x-shaped formation, leading to an explosive energy release that accelerates charged particles and drives large-scale flow in the Earth's magnetosphere. This is the main driver of magnetospheric activity—and space weather in general—causing impacts to systems ranging from the power grid to space missions.



This artist's illustration shows MMS satellites flying near the Sun-facing edge of the Earth's magnetic field. The spacecraft have made the first-ever direct detection of magnetic reconnection, an explosive energy burst, between the magnetic fields of Earth and the Sun. *(Courtesy NASA)*

The NASA Magnetospheric Multiscale (MMS) mission made a major discovery in 2016 using particle data and electric and magnetic field data from the dayside magnetosphere. It found that electrons govern the conversion of stored magnetic energy into kinetic energy and heat through reconnection. These electrons take on a meandering "figure eight" orbit, which quickly removes them from the reconnection plane and facilitates the process.

In 2018, MMS observed this same process in the Earth's magnetospheric tail, which demonstrated that it could occur in different plasma conditions. Over the last few years, MMS also revealed that reconnection is a ubiquitous process occurring throughout near-Earth space, including the magnetospheric flanks and the region of shocked solar wind called the magnetosheath.

The MMS mission—launched in 2015—is a constellation of four closely spaced satellites that measure how electrons facilitate the energy release of magnetic

Continued on next page

epomail@lasp.colorado.edu
LASP • 1234 Innovation Drive, Boulder, CO 80303-7814 • 303-492-6412 • http://lasp.colorado.edu

Mission & technical stats

- LASP operates 4 satellites.
- LASP operates 146 instruments on 18 spacecraft.
- LASP is currently developing 8 spacecraft and 15 instruments for 13 missions.

Staff stats

(September 26, 2018)

Scientific researchers	69
Tenure-track faculty	24
Visiting faculty	4
Professionals	314
Graduate students	53
Undergraduate students	92
Retirees	18
Temps	8
Total	**582**
Affiliates	239
Open positions	23

For employment information, visit http://lasp.colorado.edu/home/about/jobs.

Key hires

Jerry Jason joins LASP as the director of Mission Operations & Data Systems. He has more than 25 years of executive and flight director experience at NASA and in the private sector, most recently as Spire Global's mission operations director. Jerry has been recognized by NASA for significant leadership and achievements, including the "Steely-Eyed Missile Man" award for the STS-108 Space Shuttle Endeavor mission.

reconnection. LASP hosts the payload operations and science data centers, and helped build the electric field instrument and digital signal processing board. LASP scientists study how parallel electric fields, plasma waves, and turbulence impact the reconnection process to improve our ability to predict and mitigate the effects of solar activity on an increasingly technological society.

For more information on MMS, visit http://lasp.colorado.edu/home/missions-projects/quick-facts-mms/.

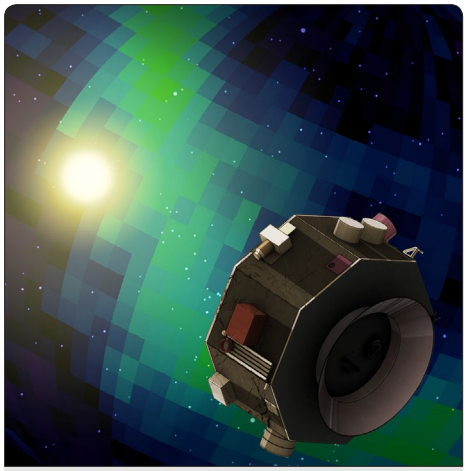
By Rick Wilder, research scientist at LASP.

LASP provides instrument and SOC for IMAP mission

The LASP Interstellar Dust Experiment (IDEX), led by co-investigators Mihály Horányi and Zoltan Sternovsky, was selected in June to be among 10 instruments onboard the Interstellar Mapping and Acceleration Probe (IMAP) mission. LASP will also provide the IMAP science operations center (SOC), led by Dan Baker.

IMAP, scheduled to launch in 2024, will operate from the Lagrange 1 point between the Earth and the Sun. The instruments onboard will make comprehensive observations of the local interstellar medium to discover the fundamental physical processes that define the boundary with our heliosphere.

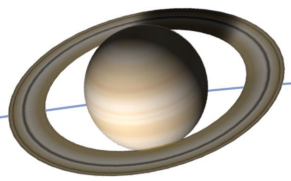
The LASP-engineered IDEX dust analyzer will detect interstellar particles and characterize their interaction with the boundary and the heliosphere. IDEX will be the most capable dust instrument ever launched and will provide the first accurate measurements of the flux, size distribution, and elemental and chemical composition of interstellar dust particles flowing through our solar system. The SOC builds on the highly successful model pioneered for the MMS mission featured in the previous story.



This illustration shows the Interstellar Mapping and Acceleration Probe observing signals from the interaction of the solar wind with the winds of other stars. *(Courtesy NASA)*

For more information on IMAP, visit http://lasp.colorado.edu/home/missions-projects/quick-facts-imap/.

By Zoltan Sternovsky, research scientist at LASP.



Mission status

Instrument Development (Pre-Phase A)
- MatISSE LAMA

Phase A/B (funded concept study)
- SPRITE CubeSat
- CIRBE CubeSat
- CLARREO Pathfinder
- Compact TIM CubeSat
- CUTE CubeSat
- FOXSI/HFSS
- IMAP IDEX
- TSIS-2

Phase C (design and fabrication)
- Europa Clipper/SUDA
- IXPE

Phase D (assembly and test)
- Emirates Mars Mission (EMM)
- GOES-T/EXIS, GOES-U/EXIS

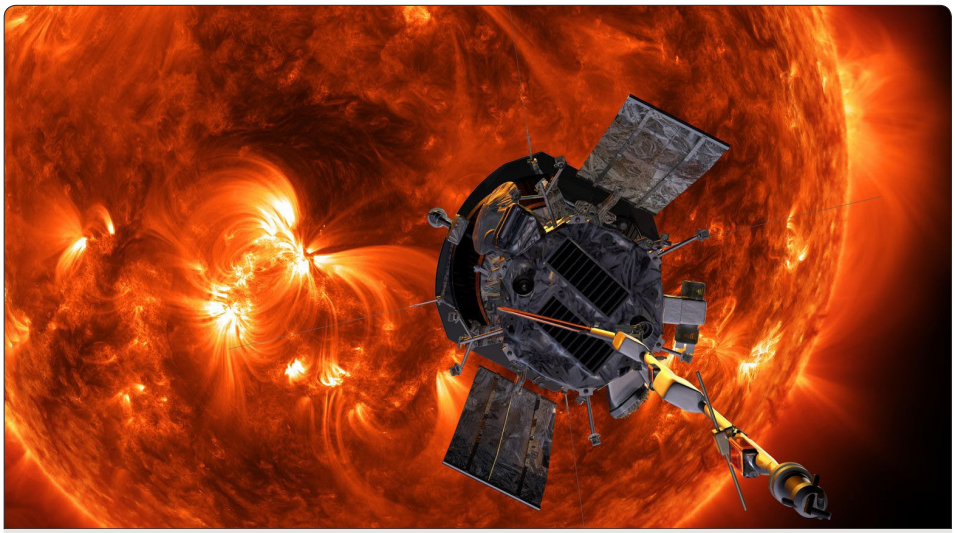
Launch/Early Orbit [launch date]
- GOES-17/EXIS [Mar. 2018]

Prime Mission [end date]
- GOLD [2020]
- TSIS-1 [2023]
- GOES-16/EXIS [2026]
- Parker Solar Probe [Aug. 2025]
- Compact SIM CubeSat [Nov. 2020]
- MinXSS-2 CubeSat [Nov. 2020]

Extended Mission [end date]
- Van Allen Probes REPT/FIELDS [2019]
- MAVEN [2019]
- SORCE [2019]
- STPSat-3/TCTE [2019]
- AIM [2020]
- MMS, four spacecraft [2020]
- SDO/EVE [2020]
- THEMIS and ARTEMIS [2020]
- TIMED/SEE [2020]
- New Horizons/SDC [2021]

For more information on current missions, as well as full instrument and mission names, visit http://lasp.colorado.edu.

Parker Solar Probe launches on a mission to "touch the Sun"



An artist's concept of Parker Solar Probe shows the spacecraft approaching the Sun. *(Courtesy NASA/Johns Hopkins University/APL/Steve Gribben)*

Parker Solar Probe launched on August 12, embarking on a historic mission to "touch the Sun." In early November, the spacecraft made its first close approach to the Sun, gathering data on the physical processes that heat the solar corona and accelerate the solar wind.

By exploring near-Sun fundamental physics, Parker Solar Probe will enhance our ability to predict space weather, and consequently, the radiation environment in which future space explorers will work and live. LASP scientists Robert Ergun and David Malaspina are co-investigators on the FIELDS experiment.

LASP designed and built the Digital Fields Board (DFB) for the FIELDS experiment. The DFB conducts critical analog and digital signal processing of scientific electric and magnetic field data, and is specially designed to operate in the challenging near-Sun environment.

Parker Solar Probe will have 24 close encounters with the Sun over the next six years—eventually coming within 6.2 million kilometers (3.85 million miles) of the Sun's surface—each time diving into the hostile near-Sun environment and each time revealing more about the Sun's mysteries.

For more information on PSP, visit http://lasp.colorado.edu/home/missions-projects/quick-facts-psp/.

By David Malaspina, research scientist at LASP.

Mission operations revolution

The LASP Mission Operations ("Ops") portfolio of projects is undergoing a transformation. The 19-year-old Quick Scatterometer mission ended with a final command to the satellite on October 2. It will spend the next ~90 years slowly deorbiting. The Kepler space telescope completed its final science campaign on October 14, after expending the last of its fuel. On November 15 the final command

was sent from LASP to Kepler, relegating it also to the realm of decommissioned spacecraft.

It's not all goodbyes though: LASP completed commissioning activities and began operating the Compact Spectral Irradiance Monitor CubeSat (CSIM) after its launch on December 3. In support of CSIM—as well as third-party and other LASP CubeSat missions like MinXSS—LASP has completed a Small Satellite Operations Center in a previously unused third-floor space.

Additionally, Ops is preparing to support launch of the Emirates Mars Mission in July 2020, and to operate the Imaging X-ray Polarimetry Explorer, slated for launch in April 2021.

For more information on LASP Mission operations, visit http://lasp.colorado.edu/home/mission-ops-data/.

By Darren Osborne, mission operations flight director at LASP.

LASP operations staff commission the CSIM and MinXSS-2 CubeSats after deployment from a SpaceX Falcon 9 rocket carrying Spaceflight's 64-satellite ride-share mission dubbed SSO-A SmallSat Express. SSO-A launched from Vandenberg Air Force Base on Monday, December 3. *(Courtesy Patricio Lujan/LASP)*

INNER SPACE

News

Goodnight Kepler

On October 30, NASA announced that the Kepler spacecraft finally ran out of fuel and will no longer hunt for planets beyond our solar system. Launched in March 2009, and operated at LASP, Kepler (later extended as the K2 mission) discovered more than 2,600 exoplanets.

"As NASA's first planet-hunting mission, Kepler has wildly exceeded all our expectations and paved the way for our exploration and search for life in the solar system and beyond," said Thomas Zurbuchen, associate administrator of NASA's Science Mission Directorate.

On November 15 at 9:05 PM MT, LASP graduate student Reidar Larsen sent the last command to the spacecraft, putting Kepler to sleep for eternity in its orbit a safe distance from the Earth. Imagine putting that on your post-university résumé.

Education and Outreach

Data visualization tool for the GOLD mission

The LASP Office of Communications and Outreach is leading communications and outreach for the NASA Global-scale Observations of the Limb and Disk, or GOLD, mission. As part of this program, which includes content management for the GOLD website, social media efforts, an ongoing webinar series, and print and visual media production, LASP is creating a web-based, interactive data visualization tool.

The data viewer will display near-real-time GOLD instrument data, along with a series of educational components to provide background information about GOLD and its science objectives. An ultraviolet imaging spectrograph built at LASP, GOLD will provide unprecedented details about near-Earth space, which receives solar energy input from above and is affected by atmospheric waves and tides from below.

The GOLD data visualization tool will enable the public to understand the complexities of the Earth's upper atmosphere and to recognize how changes in this region can impact our increasingly technological society. The tool can be found at *http://gold.cs.ucf.edu*.

Achievement awards

Fran Bagenal was awarded the prestigious AGU 2018 James Van Allen Lecture for her sustained and unique contributions to advancing the understanding of space physics and aeronomy. Named lectures offered by AGU sections recognize distinguished scientists with proven leadership in their fields of science.

Student news

Christopher Moore, who received a Ph.D. in astrophysics in December of 2017, is now a postdoctoral fellow at the Harvard-Smithsonian Center for Astrophysics.

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To view LASPSpace archives, visit http://lasp.colorado.edu/home/about/publications/newsletters/.

Dan Baker is the 2018 recipient of the AGU William Bowie Medal. As the highest honor given by the organization, only one is awarded each year and previous recipients include James A. Van Allen. The award—given for "outstanding contributions for fundamental geophysics and for unselfish cooperation in research"—recognizes Baker's exceptional scholarship and leadership in space science and the broader field of space weather and solar physics.

Baker was also awarded the European Geosciences Union (EGU) 2019 Hannes Alfvén Medal, bestowed for outstanding scientific contributions towards the understanding of plasma processes in the solar system and other cosmical plasma environments. The medal recognizes Baker's important contributions to, and leadership in, the Earth, planetary, and space sciences and will be presented at the EGU General Assembly, in Vienna in April.

Justin Deighan won the 2018 NASA Early Career Public Achievement Medal. The medal is awarded to non-government employees for unusual and significant performance during the first 10 years of their career in support of the NASA Mission. This is a notable achievement, in that, for someone at such an early phase of a career, the award recognizes substantial improvement in the discipline area.

Bill McClintock was awarded the 2018 NASA Distinguished Public Service Award. This is NASA's highest form of recognition awarded to a non-government individual. The recipient's contributions must reach a level of excellence that has made a profound or indelible impact on NASA mission success, and thus is so extraordinary that other forms of recognition by NASA would be inadequate.

Administrative update

New SmallSat operations center online

LASP recently completed final preparations of a new Small Satellite Operations Center (SSOC) to support the launch, commissioning, and flight operations of the MinXSS-2 and CSIM CubeSats, which launched December 3 on SpaceFlight's SSO-A rideshare mission.

The communications ground network currently consists of a UHF antenna and a 4.2m S-band dish, both on top of LASP's Space Technology Building, along with a UHF antenna system in Fairbanks, AK. The SSOC will offer mission operations services to the small satellite community now that the MinXSS-2 and CSIM satellites have been commissioned.

Efforts are underway to connect the SSOC to remote antennas located at National Central University in Taiwan, Nanyang Technological University in Singapore, and at LATMOS in France. Establishing this operations network is a major milestone in LASP's ability to support the expanding need of the space community for small satellite operations.