



Planetary Science

MSFC planetary scientists are active in research at Marshall, building on a long history of scientific support to NASA's human exploration program planning, whether focused on the Moon, asteroids, or Mars. Research areas of expertise include planetary sample analysis, planetary interior modeling, and planetary atmosphere observations. Scientists at Marshall are involved in several ongoing planetary science missions, including the Mars Exploration Rovers, the Cassini mission to Saturn, and the Gravity Recovery and Interior Laboratory (GRAIL) mission to the Moon.

Marshall is the center for program management for the Agency's Discovery and New Frontiers programs, providing programmatic oversight into a variety of missions to various planetary science destinations throughout the solar system, from MESSENGER's investigations of Mercury to New Frontiers' forthcoming examination of the Pluto system. Marshall also provides formal and informal scientific guidance on an as-needed basis to program-level activities, internal and external projects and proposals, and other related activities such as the Small Business Innovation Research in Lunar Science Instruments and Technology managed at Marshall.

Peering into the history of the solar system

Marshall planetary scientists use multiple analysis techniques to understand the formation, modification, and age of planetary materials to learn about their parent planets. Sample analysis of this type is well-aligned with the priorities for scientific research and analysis in NASA's Planetary Science Division. Multiple future missions are poised to provide new sample-analysis opportunities.

The centerpiece of the Marshall efforts is the Marshall Noble Gas Research Laboratory (MNGRL), a unique facility within NASA. Noble-gas isotopes are a well-established technique for providing detailed temperature-time histories of rocks and meteorites. The MNGRL lab uses Ar-Ar and I-Xe radioactive dating to find the formation age of rocks and meteorites, and Ar/Kr/Ne cosmic-ray exposure ages to understand when the meteorites were launched from their parent planets.



The MNGRL features a laser extraction line coupled to a noble-gas mass spectrometer for analysis of planetary microsamples.

The MNGRL lab was designed to study diverse problems in planetary science.

Current projects include:

1. The early impact history of the Moon through noble-gas dating of impact-melt rocks contained in lunar meteorites and Apollo breccias
2. The impact history of the asteroid belt by examination of meteorite breccias from large main-belt asteroids
3. Age limits on terrestrial impact craters
4. Ages and thermal history of unusual meteorites.

The MNGRL lab and scientific projects is supported with a diverse and sustainable portfolio of research and analysis funding.

Environmental analysis for human and robotic exploration missions

The Center's planetary scientists provide Agency expertise in planetary surface environments and mission operations. Marshall contributed to the NASA Natural Environments Definition Document/Design Reference documents that define engineering boundary conditions for the Moon. Marshall scientists also serve on internal NASA committees such as the Optimizing Science and Exploration Working Group (OSEWG), and on

Agency-wide teams to refine design reference missions and Concepts of Operation for human deep space exploration missions to Earth-Moon L2, Near-Earth Asteroids, and the Martian moons Phobos and Deimos in support of the ongoing Human Spaceflight Architecture Team (HAT). Continued collaboration between science, engineering and operations is crucial for future expeditions, and Marshall planetary scientists continue to support these efforts.

Pathfinding support for mission operations on other worlds

Since 2009, Marshall scientists have been part of the D-RATS science team, providing geological context and traverse protocols for crew activities, as well as being part of the science backroom to integrate science observations with mission operations. The science backroom has been based both on the Apollo and Mars Exploration Rover (MER) operation models, where traverse activities are understood in real time, using suit-mounted and rover-based video streams and data. These models emphasize the need for scientists to analyze and interpret information on timescales that are unusually short (minutes to hours) by remote sensing or robotic mission standards, which presented significant challenges. Nonetheless, test metrics show that real-time data return to the backroom allows for both greatly improved field operations and scientific return.

Dr. Barbara Cohen (second from left) served as the Science Lead in the remote science backroom at the European Space Agency for Desert-RATS 2011.



Lunar seismology enables future planetary geophysical analysis

Of all the bodies in the solar system, the Moon is uniquely accessible for both orbit- and ground-based geophysical studies, and the recent increase in both domestic and international lunar missions emphasizes this fact. The geophysical experiments deployed on the lunar surface during Apollo remain the benchmark for ground-based studies on other planets. As such, ongoing analysis of this unique data set continues to yield new information relevant to the Moon's formation and evolution, and encourages the development of data analysis techniques that can be applied to future planetary geophysical data.

Marshall planetary geophysics work focuses on continued analysis of data returned by the Apollo Passive Seismic Experiment, a network of four seismometers deployed on the lunar surface between 1969 and 1972. Data from these instruments were recorded continuously until late 1977. Several types of seismic signals were recorded, including natural impacts (meteoroids), artificial impacts (stages from the Apollo spacecraft and the landers themselves), shallow moonquakes (natural events occurring in the upper 50 to 220 km of the Moon), and deep moonquakes (natural events occurring between 700 and 1000 km depth).

Recently, an analysis of the deep moonquake data identified seismic energy reflecting off the Moon's core, and confirmed the presence of solid, molten, and partially molten layers. The size, composition, and present state of the layers of the lunar interior are relevant to many topics concerning the formation and early evolution of the Moon. Using the core as an example,

its size acts as a constraint in impact formation models. Its composition is used to infer the origin of present-day remnant magnetization observed in lunar samples (e.g., an iron core may once have provided the early dynamo necessary to support magnetic field generation). Its current state (molten vs. solid) is relevant to thermal evolution models.

Advancing our understanding of the Moon's interior is critical for future scientific investigations and exploration missions. The Moon's lack of Earth-like plate tectonics means that a record of early planetary differentiation has been preserved. With that in mind, future ground-based missions can build on the legacy of Apollo by designing instruments capable of addressing deficiencies in the existing lunar data.



Dr. Renee Weber's study of Apollo seismic data determined that the lunar core is about 60% liquid by volume.

Studying remote atmospheres and atmospheric dust

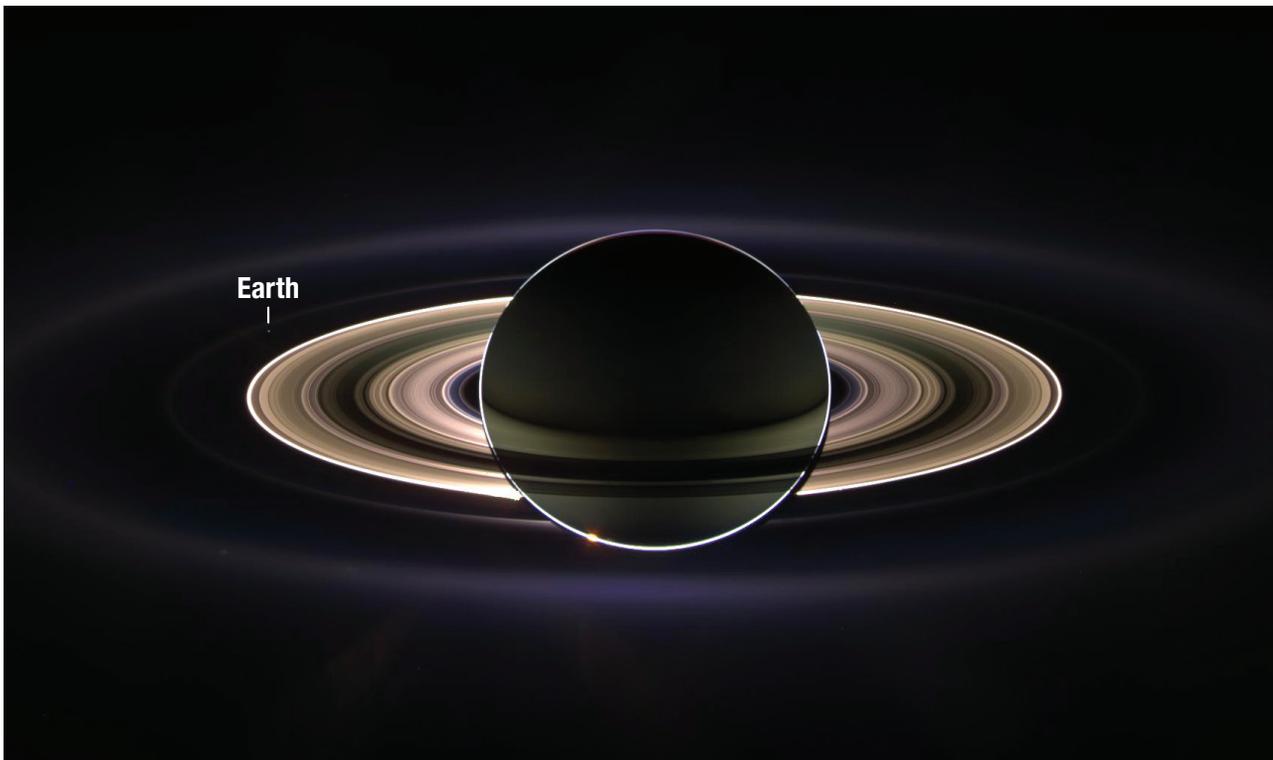
Marshall planetary atmospheric studies have been developed over many years for remote sensing of planetary atmospheres, with application in particular to Mars, Jupiter, Saturn and its largest satellite Titan, Uranus, and Neptune, as well as the Earth. These programs have been employed for several NASA earth and planetary atmospheric infrared spectroscopy programs with ground-based, balloon-borne instruments, as well as on Space Shuttle and other spacecraft platforms.

Marshall scientist Dr. Mian Abbas is a co-investigator for the Cassini Infrared Spectrometer (CIRS) instrument on the international Cassini mission, conducting observations of Saturn and its moon Titan to measure atmospheric thermal structure, gas abundances, isotopic ratios for Saturn/Titan, wind speeds and cloud structure, Saturn's rings and its satellites.

Analyzing dusty plasma to understand interstellar and planetary environments

Dr. Abbas is also engaged in the study of the physical and optical properties of interstellar and planetary dust grains, which account for approximately half of all elements in the interstellar medium that are heavier than helium. Micron and sub-micron cosmic dust grains play an important role in the physical and dynamical processes in the galaxy, as well as planetary and interplanetary environments.

An experimental facility based on electrodynamic balance has been developed at Marshall for investigation of the properties of individual micron/sub-micron size dust grains in simulated space environments. This Dusty Plasma Laboratory has conducted several first-of-their-kind experiments to study different properties and processes of astrophysical and lunar interest.



This image of Saturn captured by Cassini revealed previously unknown faint rings of dust around the planet.

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