CASSINI–HUYGENS MISSION TO SATURN

JET PROPULSION LABORATORY

Saturn and its mysterious moon Titan are the primary destinations of the Cassini–Huygens mission, a project developed by the National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), the Italian Space Agency (Agenzia Spaziale Italiana, ASI), and several separate European academic and industrial contributors. The Cassini–Huygens mission is managed for NASA by the Jet Propulsion Laboratory (JPL) of the California Institute of Technology. The Cassini spacecraft was launched on a Titan IVB/Centaur rocket on October 15, 1997, from Cape Canaveral, Florida.

The Cassini–Huygens mission honors two 17th-century astronomers who pioneered observations of Saturn: Jean-Dominique Cassini, who discovered several satellites as well as ring features such as the Cassini division, and Christiaan Huygens, who discovered the planet's largest satellite, Titan. The Cassini mission's objective is a four-year, close-up study of the Saturnian system, including Saturn's atmosphere and magnetic environment, its rings, several moons, and Titan. The mission represents a rare opportunity to gain significant insights into major scientific questions about the creation of the solar system and pre-life conditions on Earth, in addition to a host of questions specific to Saturn.

The Cassini spacecraft fires one of its two redundant main engines for 94 minutes to slow down enough to be captured into orbit around Saturn.

MYSTERIES OF SATURN AND TITAN

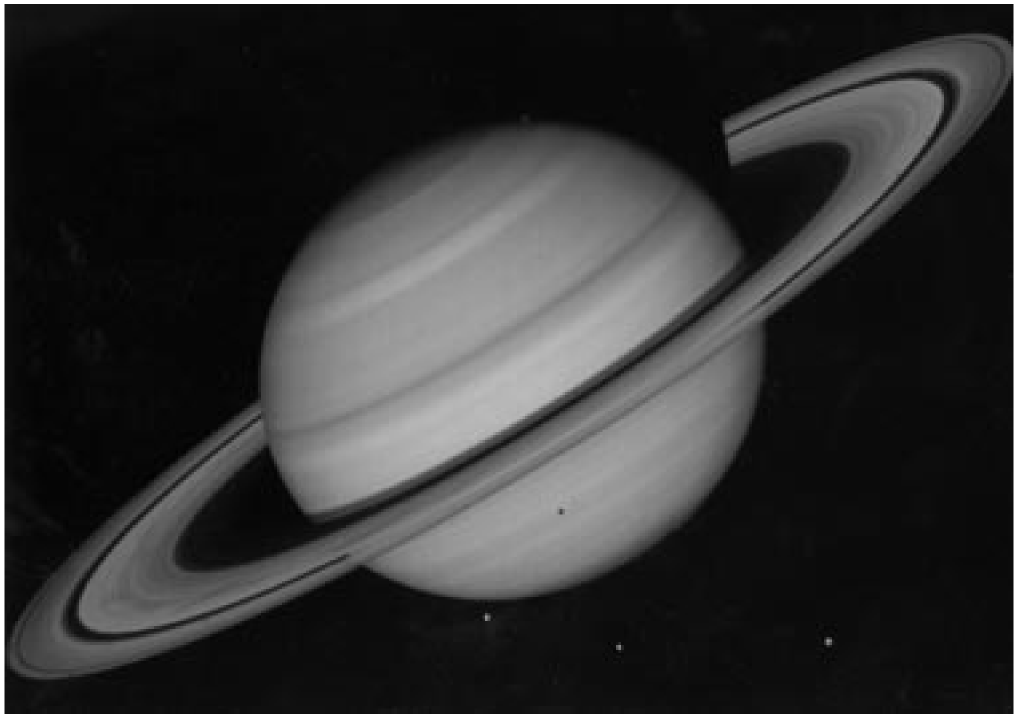
Saturn, its rings, and its moons hold clues to understanding the origins of our solar system. A detailed study of the rings and icy satellites may reveal information about the material from which Saturn formed and evolved. Saturn's atmosphere shows fewer features than that of Jupiter, perhaps due to more vigorous mixing of various constituents and the fact that temperatures necessary for cloud condensation occur deeper in the atmosphere. Saturn's atmospheric phenomena also include jet streams that are among the fastest in the solar system.

Titan, Saturn's largest moon, also holds its own unique mysteries. What goes on beneath Titan's organically rich, primordial Earth–like atmosphere? Voyager spacecraft data and Earth-based radar and infrared observations suggest that there may be continents as well as oceans or lakes of liquid ethane on Titan. What planetary processes might be occurring in such a cold environment, where water ice is so cold that it is as hard as rock? These are among the questions Cassini and its Huygens Titan probe will address during the mission.

THE PATH TO SATURN

To accomplish Cassini's objectives, the NASA-provided orbiter and ESA-provided probe carry sophisticated instrumentation, for a total of 27 scientific investigations. Funding is provided by NASA and its international partners from Europe. The mission will produce the most complete information about a planetary system ever obtained.

Cassini executes two gravity-assist flybys of Venus — one in April 1998 and one in June 1999 — then a flyby of Earth in August 1999 and a flyby of Jupiter in December 2000. Cassini's Sun-relative velocity will increase as it swings around each planet, allowing the spacecraft to



Saturn, the sixth planet from the Sun, holds clues to the origin of our solar system.

reach distant Saturn by July 2004. When Cassini arrives at Saturn, an onboard rocket engine will fire to brake the spacecraft into the first of some six dozen orbits around the planet.

In late 2004, the orbiter will adjust its trajectory and release the Huygens probe for its three-week coast to Titan. After atmospheric entry and parachute deployment, Huygens will slowly descend to the surface of Titan. The instrument-laden probe will beam its measurements to the Cassini orbiter, where the information will be stored and then relayed to Earth.

During the mission, the orbiter will execute more than four dozen close flybys of particular bodies of interest — including more than three dozen encounters of Titan as well as several close flybys of selected icy satellites. In addition, the orbiter will make at least two dozen more distant flybys of the other Saturnian moons. The changing inclination of the orbits will also allow study of Saturn's polar regions and equatorial zone.

SCIENCE AT SATURN AND TITAN

Chief among Cassini's scientific goals is a thorough characterization of Titan. Like Earth, Titan has a nitrogen-rich atmosphere. Complex organic molecules make up the haze that clouds its surface from view. These molecules constantly form and slowly fall to Titan's surface. Determining the chemistry of Titan's atmosphere may be crucial to understanding the evolution of early life on Earth.

A large portion of the Cassini mission's Titan studies will be accomplished by the Huygens probe, which will be released from the orbiter and parachute through Titan's opaque atmosphere. During the descent, which may last up to 2-1/2 hours, Huygens' camera will capture more than 1,100 images; other instruments will directly sample Titan's atmosphere and determine its composition. There is a possibility that the probe will continue to return science data, including images, directly from Titan's surface.

Titan exploration will also be carried out by imaging radar, which passes signals through clouds or atmospheric haze and showers the surface of its target with a swath of radar pulses. Characteristics of the returned radar signals are processed to create detailed images of the terrain. Imaging radar has been used to great advantage in mapping cloud-covered regions of Earth where most other mapping instruments cannot "see" the surface, and was used on NASA's Magellan spacecraft to produce a global terrain map of cloud-enshrouded Venus. Near-infrared mapping may also reveal Titan's surface features.

One Cassini instrument will produce an image of reactions within Saturn's magnetosphere — the magnetic "bubble" that surrounds the planet. The instrument will obtain images of the active regions of the plasma envelope surrounding Saturn and its moons, including Titan. This pioneering investigation will open a new observational window into the study of the Saturn system. An array of sensors will study the magnetic field structure, the neutral and charged particles, and the radio waves generated by interactions of the magnetosphere with the solar wind and bodies within the Saturn system.

RINGS UPON RINGS

Saturn's magnificent rings are, of course, a leading target for study. Explorations by the Voyager 1 and 2 spacecraft showed that the rings are made up of thousands of individual ringlets — which themselves were found to be largely composed of ice particles ranging in size from those of sugar grains to large boulders. Slight color variations indicate that the rings include some rocky material. Even these short-term Voyager studies showed a wide range of unexplained phenomena in the rings, including various wave patterns, small and large gaps, clumping of material, dark "spokes," and small "moonlets" embedded in the rings. Did moons break apart to provide the source of ring material as a result of comet or meteoroid strikes, or from tidal effects within Saturn's strong gravity field? Long-term, close-up investigation of the rings by Cassini's instruments will help scientists answer these questions and better understand the processes that led to the formation and evolution of this relatively young ring system.

As Saturn orbits the Sun, the changing angle of sunlight illuminating the rings dramatically alters their visibility. Cassini's arrival at Saturn is timed for optimum viewing of the rings, during a period when they will be well-

The Huygens probe carries six science instruments to sample Titan's atmosphere and surface properties.

Saturn has 18 known satellites. This composite image includes six. Seen clockwise from upper right are Titan, Mimas, Tethys, Dione, Enceladus, and Rhea.

illuminated by sunlight. Orbiting Saturn, Cassini will be able to detect small moonlets inside the rings, determine the compositions of the particles, study the interactions of the rings with the magnetosphere, and conduct intensive observations of ring dynamics over a four-year period.

Applied to larger-scale disk-type systems, the detailed studies of Saturn's rings by Cassini will provide important contributions to theories about the origin and evolution of the dust and gas from which the planets formed. Additional consideration of the Saturn system as a microcosm may be applicable to examinations of even larger disk systems so common in the universe, including our home galaxy, the Milky Way.

THE ICY SATELLITES

Among the icy satellites to be explored is Enceladus, which is made almost entirely of water ice and has great regional differences in the number of impact craters on its surface. Cassini will determine if Enceladus has some internal heat source that melts the ice enough to erase impact craters. Instruments will search Enceladus for small, geyser-like volcanoes. Some scientists suspect that such volcanoes may shoot ice particles into space, where they are captured by Saturn's gravity and become part of the planet's E-ring.

The moon Iapetus will be studied because of its unique surface. Half the moon is snow-bright, while the other half is as dark as asphalt and thought to contain complex organic compounds. Cassini will help determine the surface composition of Iapetus, discover the nature of the dark matter, and determine whether the material came from within the moon or was deposited from another source.

FOR MORE INFORMATION

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