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Cassini-Huygens: Recent Science Highlights and Cassini Mission Archive

Linda Spilker (1) and Scott Edgington (1)
(1) Jet Propulsion Laboratory/California Institute of Technology, California, USA (linda.j.spilker@jpl.nasa.gov)

Abstract

Cassini and Huygens were the most distant planetary orbiter and probe ever launched, arriving at Saturn in 2004. For the next 13 years, through its prime and two extended missions, and over almost half a Saturnian year, this spacecraft made astonishing discoveries, reshaping and fundamentally changing our understanding of this unique planetary system [1]. During this time period, Cassini collected an amazing data set, interleaving hundreds of targets, and tens of thousands of planned observations. Faced with the end of the mission in September of 2017, the Cassini Project embarked on an ambitious effort to archive its collected data and higher-order products in a manner that would enable future scientists and engineers to access its content. Teaming up with NASA's Planetary Data System (PDS), the Cassini Project developed the Cassini Mission Archive web pages to meet this goal. Recent science highlights and the Cassini mission archive will be discussed.

1. Saturn System Exploration

Cassini and Huygens science instruments were selected in 1990 and Cassini/Huygens was launched in 1997. After a 7-year, 2.2 billion-mile journey from Earth, Cassini arrived at Saturn and dropped a parachuted probe named Huygens to study the atmosphere and surface of Titan. For 13 years, beginning in 2004, Cassini circled Saturn, making astonishing discoveries about the planet, moons and rings [1].

Low on fuel, the mission ended with a fiery plunge into Saturn's atmosphere on September 15, 2017. Cassini sent back its final bits of unique science data as it plunged into Saturn's atmosphere, vaporizing and satisfying planetary protection requirements. Cassini/Huygens examined the Saturn system in greater depth than ever before and shed light on many of the mysteries uncovered by Voyager.

2. Recent Science Highlights

Closest flybys to ringmoons and rings. In late 2016, a close flyby of Titan changed Cassini's trajectory to a series of 20 Ring Grazing orbits with peripases located within 10,000 km of Saturn's F ring. These orbits included the closest flybys of tiny ring moons, including Pan, Daphnis and Atlas [2] (Figure 1), and remarkable views of the Daphnis-created wave on the edge of the Keeler gap. These orbits also provided some of the mission's highest-resolution views of Saturn's F ring, and A and B rings, and prime viewing conditions for fine scale ring structures such as propellers (Figure 1) and wispy clumps in the rings [3].

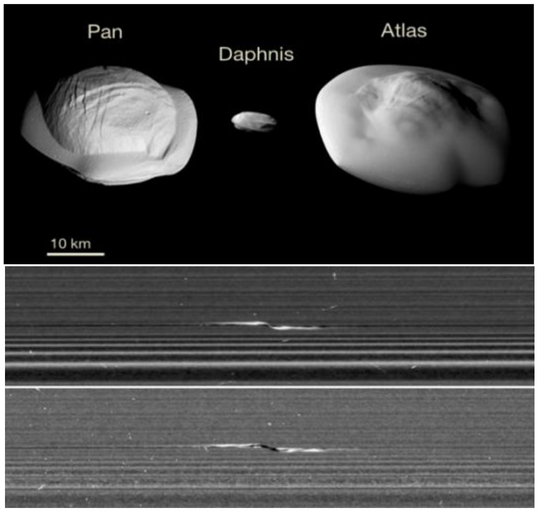

Figure 1: Comparison of the ring moons, Pan, Daphnis, and Atlas (top). Ring propeller Santos-Dumont on lit (middle) and unlit (bottom) sides of Saturn's rings.

Saturn's gravitational field and ring mass. In late April 2017, a final close flyby of Titan propelled Cassini across Saturn's main rings and into its Grand Finale orbits between the D ring and planet. Saturn's gravitational field was measured to unprecedented accuracy, providing constraints on the interior structure of the planet, including deeply rotating layers to a depth of 9,000 km, and a core of 15-18 Earth masses [4]. Saturn's ring mass was measured also, and the rings are 45% less massive than previous estimates from Voyager data [4]. This result indicates a ring age of between 10 and 100 million years old, much younger than the age of the solar system.

Depth and composition of Titan's lakes. During Cassini's final flyby of Titan in April 2017, Cassini's radar instrument measured the depth of Titan's north polar lakes at around 100 m, and found their composition to be almost pure methane [5]. These lakes are not interconnected by river channels, but instead are connected to a reservoir of methane below the surface. Some lakes were also seen to evaporate as seasons changed on Titan [6].

3. Cassini's Mission Archive

The goal of the Cassini Mission Archive was to simplify access to the complex Cassini data sets through a series of web pages to help find and analyse the data, all stored within NASA's PDS. The Cassini project also developed an architecture to organize data by each of the science teams and disciplines as a "one-stop shop" for Cassini data and supporting resources.

As part of Cassini's legacy, its science teams and discipline experts generated and delivered the most valuable research support data, organized observations for users, and identified high-value scientific measurements. The Cassini project generated and delivered search & visualization tools to help find and evaluate data in a context that supports scientific questions. Some examples of the Cassini Mission Archive web pages at PDS include:

Science-Themed Pages. Cassini science has traditionally been divided into five discipline areas: Saturn, Rings, Magnetosphere, Icy Satellites, and Titan. Theme pages were developed with products useful to that discipline, for example:

- Timeline visualizations for Saturn observations
- Summary table for Ring properties
- Magnetospheric event lists and reference models
- Observation tables for Titan, Enceladus, and other moons
- Written summaries and collections to capture the intent of the observations.

Instrument-Specific Pages. The Cassini Mission Archive includes 12 instrument pages each containing a high-level description of an instrument and specific details on the data that it returned, with links to:

- Instrument-specific Users' Guides
- Science-support information and tools for the analysis of that instrument's data
- Observation descriptions and links to science data

Search and Analysis Tools. During the course of developing the Cassini Mission Archive, the Cassini Project determined that several tools already existed on the PDS to help assist with finding appropriate datasets, and further augmented those tools for Cassini:

- Outer Planets Unified Search and Image Atlas
- WebGeocalc spacecraft geometry calculator
- Cassini Events Calendar for quick searches
- Titan Trek geographic information system to help find and preview remote sensing data

Spacecraft Events and Configuration. Certain events and configurations on the spacecraft itself affected the science data. This information has been collected to help scientists properly understand and analyse the data, including, but not limited to: Noise sources. Calibration details, Navigation information, and Data gaps.

Acknowledgements

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